GUIDE

TO THE

URINO-CHEMICAL CHEST.

R. VENABLES.

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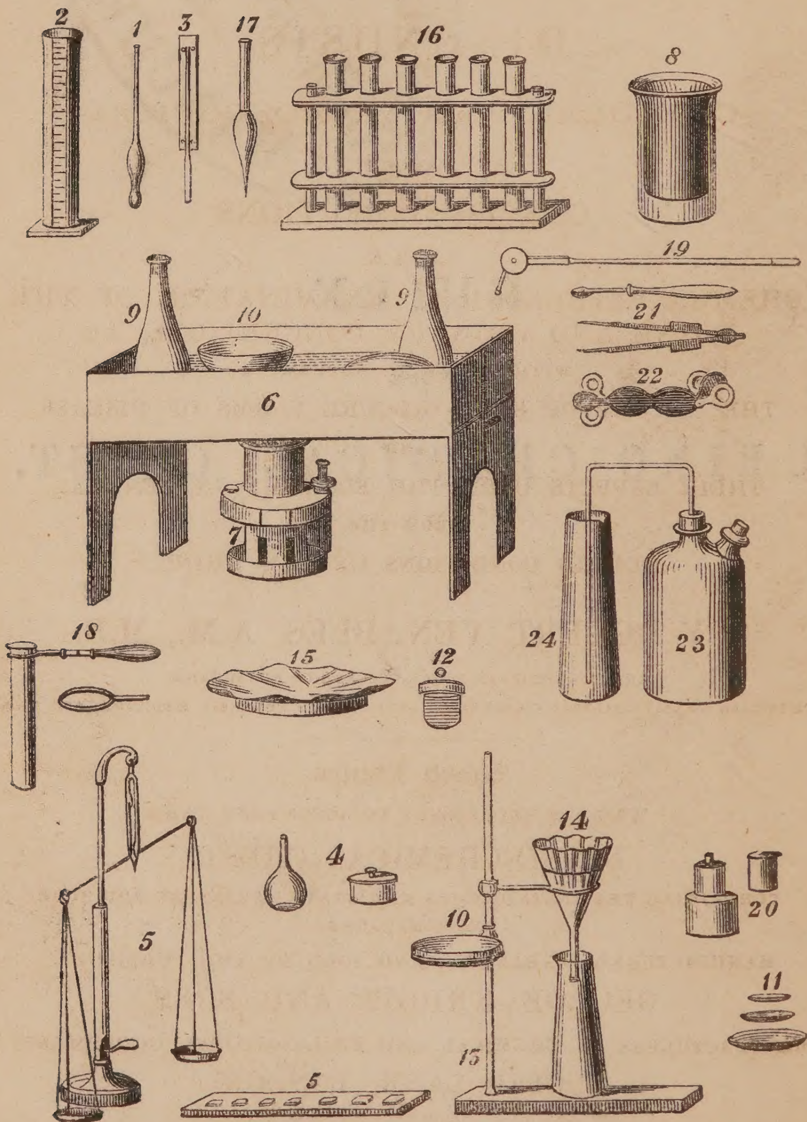
URINO-CHEMICAL CHEST.

THE APPARATUS AND INSTRUMENTS

CONTAINED IN

THE URINO-CHEMICAL CHESTS.



ELEMENTS

OF

URINARY ANALYSIS

AND

DIAGNOSIS,

CHEMICAL AND MICROSCOPICAL:

BEING

CONCISE DIRECTIONS

FOR A

CHEMICO-PATHOLOGICAL EXAMINATION OF THE URINE AND URINARY CONCRETIONS, &c.,

WITH A VIEW TO DETERMINE

THE NATURE OF SOME OBSCURE FORMS OF DISEASE,

AND

THEIR EFFECTS UPON THE ECONOMY IN GENERAL,

FROM THE

MORBID CONDITIONS OF THE URINE.

BY ROBERT VENABLES, A.M., M.B.

INCEP. CANDIDATE ROYAL COLLEGE OF PHYSICIANS,

PHYSICIAN TO THE DIABETIC DISPENSARY, LECTURER ON FORENSIC MEDICINE, ETC., ETC.

Second Edition.

WRITTEN EXPRESSSLY TO ACCOMPANY THE

URINO-CHEMICAL CHEST,

CONTAINING THE INSTRUMENTS AND TESTS NECESSARY FOR SUCH EXAMINATIONS.

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URINARY ANALYSES EFFECTED, ETC.

PREFACE.

Although the conditions of the urine appear so eminently calculated to throw light upon many of the more obscure forms of disease, it seems surprising that the subject has not yet met with that general attention which it merits. In other cases, the investigation and development of morbid phenomena have indeed been cultivated with a zeal and success unknown to former periods. As instances, I may notice percussion and auscultation in the diagnosis of diseases of the chest; yet it was not without opposition that these means were admitted into practice.

It has occurred to me frequently to observe persons determined to devote themselves to the study of the conditions of the urine as an auxiliary to diagnosis; but, having commenced, they have given up the pursuit in despair, because during their investigations either apparatus or tests have been required, which their forethought had not provided.

It is, however, only by the united efforts of numbers that knowledge can be really and truly advanced, and for the investigation under consideration perhaps but an ordinary knowledge of chemistry is essentially necessary. It was therefore with no small degree of regret that I observed persons, whose abilities were competent and whose opportunities were ample, give up such inquiries, either from disappointment and vexation, or from an apprehension of the great extent and refinement of the

chemistry requisite for success. Upon reflection, it occurred to me that if all the most useful apparatus and tests were collected together and placed at the command of the practitioner, one great difficulty would be removed, and perhaps an impulse given to this method of diagnosis and pathology. With this view I mentioned the matter to Mr. Knight, of Foster Lane, who entered warmly and with unusual zeal into the subject; and being furnished with an outline of the principal chemicals and apparatus, he constructed this most compact, and I will venture to assert, most useful little cabinet. It contains all the apparatus and tests necessary for an elaborate series of experiments upon the urine; and at Mr. Knight's request I prepared the little summary of directions for the general use of the apparatus, and application of the chemicals, &c. contained in the cabinet. Indeed, the compactness of the apparatus will enable the operator to perform almost every variety of experiment, whether boiling, distillation, evaporation, &c. &c. not only with great ease and facility, but almost immediately, under all circumstances, and in every situation; while the size and lightness of the cabinet render it so portable, that it may accompany the practitioner, without any inconvenience, when called to a distance, and enable him to make analyses on the moment, which would not be possible if delayed for any length of time. Such as it is, however, I beg to recommend it to the notice of the Profession. It will be found that nothing has been spared to render it as complete and as compact as possible; and I have no doubt that it will prove a valuable assistant in the investigation of urinary disorders.

ROBERT VENABLES.

9, *Finsbury Circus*,
London, 1843.

PREFACE

TO THE SECOND EDITION.

A TOLERABLY large edition of the present work having been some time since exhausted, I have been called upon to prepare another. The repeated applications to the publishers for a further supply are in themselves sufficient proofs of the opinion of the profession, even though such opinion were not supported by the favourable notices of the press on its first appearance. In order to render the present edition equally deserving, I have bestowed upon it all the attention I possibly could; and to this desire may, in a great degree, be attributed the length of time which has elapsed between the consumption of the former and the appearance of the present edition.

An elementary essay like this could hardly be expected to enter into that length of detail and history which might be expected in a systematic work. I have therefore confined myself to what alone can prove practically useful.

In describing the modes of analysis, I have chosen those which are most easy of application, and such as may be readily practised or conducted by even the least versed in chemical manipulation. I have also endeavoured to point out to the unpractised analyst methods by which he can hardly fail to obtain the information he seeks.

In the first edition, I omitted all reference to microscopical inquiry; and this perhaps may have seemed unintelligible to those who have witnessed my constant

appeal to the microscope in the lectures which I deliver upon urinary diseases. But the microscope, as an auxiliary in pathological inquiry and diagnosis, had not *then* excited that professional interest which it has since acquired;—an interest to which, I have the vanity to imagine, my unceasing efforts have in some degree contributed.

I have therefore improved this edition by presenting the reader with the easiest methods of microscopical investigation, and have laid before him the forms and appearances which urinary deposits present when viewed through the microscope; and to render the similarities the more complete, the forms are represented as if viewed upon glass slides or supports resting upon the stage of the instrument. Such as it is, I send this essay forth, leaving it to its merits to abide its fate.

9, *Finsbury Circus,*
May, 1850.

CONTENTS

OF THE

URINO-CHEMICAL CHEST,

WITH A SHORT SPECIFICATION OF THEIR USE.

---

1. PROUT'S URINOMETER.
   To be immersed in the urine the sp. gr. of which we are desirous of ascertaining.
2. GLASS JAR FOR DITTO.
   For containing specimens to be examined.
3. THERMOMETER.
   For determining the temperature at the time of the examination.
4. SPECIFIC GRAVITY BOTTLE, CONTAINING 500 GRAINS AND COUNTERPOISE WEIGHT.
   For determining with greater accuracy the sp. gr. of the urine.
5. SCALES AND DECIMAL GRAIN WEIGHTS, WITH BRASS SUPPORT.
   Required to weigh the above bottle.
6. PORTABLE SAND-BATH.
   Filled with fine sand, and placed over the argand lamp—a convenient mode of applying a moderate heat to vessels placed on the hot sand.
7. ARGAND LAMP.
   To apply heat.
8. NEST OF GLASS BEAKERS.
   For containing matters to be heated or fused for the inducing those reactions which require an elevated temperature for their development.
9. SMALL GLASS FLASKS.
   For a similar purpose.

10. THREE SMALL BERLIN-WARE DISHES OR CAPSULES.

To apply heat to matters which cannot well be put into the flasks, and to observe those reactions which are best observed on a white ground; for instance, the action of nitric acid on the lithic succeeded by that of ammonia.

11. THREE GLASS EVAPORATING DISHES OR CAPSULES.

To discover excess of urea by adding nitric or oxalic acid to the urine supposed to contain it, evaporation, and other similar purposes.

12. GLAZED PORCELAIN CRUCIBLES.

For the ignition of saline matters, &c.

13. SMALL RETORT STAND.

On which to rest the apparatus when exposed to the direct heat of the argand lamp.

14. FILTERING FUNNELS AND PAPER.

Their use requires no explanation.

15. FILTER DRIER.

To dry the filters with their contents: the drier, being porous, absorbs and conveys away the moisture.

16. SIX TEST TUBES AND STAND.

In which to place specimens of urine to which to apply the different tests, so as to observe the action of several tests upon one particular specimen.

17. GLASS PIPETTE.

Very useful for applying a small quantity of any of the re-agents; or withdrawing fluids from sediment when subsided.

18. TEST TUBE AND WATCH GLASS HOLDER.

Required for supporting either of the above over the flame of the lamp.

19. BLOWPIPE.

With which to direct the flame of the spirit-lamp upon refractory particles for fusion—as the triple calculus; silex and soda, phosphate of lime, which will not fuse without a flux.

20. SPIRIT-LAMP WITH GROUND CAP.

For the blowpipe.

21. PLATINUM FORCEPS, SPOON, FOIL, AND WIRE.

To hold specimens or fragments of calculi in the flame of the blowpipe, to ascertain the effects of intense heat, as to their capabilities of being fused or not.

22. MAGNIFYING GLASS.

To observe the appearance of minute particles, both before and after being acted on by the blowpipe, form of crystal, &c.

23. BOTTLE AND CONDUCTING TUBE FOR GENERATING SULPHURETTED HYDROGEN.

The application of this instrument must be obvious on inspection.

24. TWO PRECIPITATING JARS.

For collecting precipitate in quantity.

CHEMICAL TESTS.

1. SULPHURIC ACID.

Poured on the mixture of sulphur and iron filings, produces sulphuretted hydrogen in abundance.

2. NITRIC ACID.

Discovers urea in excess, lithic acid, and albumen.

3. HYDROCHLORIC ACID.

Precipitates lithic acid and dissolves the phosphates.

4. OXALIC ACID.

Precipitates lime and crystallizes urea.

5. ACETIC ACID.

A few drops ought to be added before testing with ferroprussiate of potash for albumen, chyle, fibrin, &c.

6. TARTARIC ACID.

In excess precipitates potash, and separates it from soda.

7. ALCOHOL.

Useful to separate urea and sugar.

8. AMMONIA.

Precipitates earthy phosphates.

9. OXALATE AMMONIA.

Precipitates lime as an oxalate, and is more delicate than free oxalic acid.

10. NITRATE OF BARYTA.

Detects sulphuric acid, free or combined.

11. SULPHURIC ÆTHER.

Detects pus, by dissolving the oily envelope which distinguishes this from mucus.

12. ACETATE OF LEAD.

Frees the urine from organic and saline principles which would obscure or embarrass our search for sugar.

13. PURE POTASH.

Detects sugar in diabetic urine, and precipitates earthy bases.

14. SULPHATE OF COPPER.

Detects sugar in diabetic urine. This test and the one by potash, when they confirm each other, prove the presence of sugar beyond doubt.

15. CARBONATE OF SODA.

Precipitates phosphates and earthy bases; useful also for fusion, &c.

16. NITRATE OF SILVER.

Precipitates hydrochloric acid, as chloride of silver; and useful for several other reactions.

17. FERRO-CYANIDE OF POTASSIUM.

Detects and precipitates albumen, fibrin, &c.

18. PERMANGANATE OF POTASH.

Converts the carbon of sugar into oxalic acid, forming oxalate potash; the acid may be separated by chloride calcium.

19. TWENTY-THREE PARTS BEST IRON FILINGS, AND FIFTEEN PARTS SULPHUR, CAREFULLY MIXED.

A portion of this mixture put into the bottle (23), and as much water poured on as will form a paste, and placed by the side of the fire for two hours, yields sulphuretted hydrogen in abundance, when acted on by dilute sulphuric acid.

20. LITMUS PAPER.

For indicating acidulous reaction.

TURMERIC PAPER.

For indicating alkaline reaction.

CONTENTS.

ELEMENTS

OF

URINARY ANALYSIS,

ETC.

It is a well established fact, that a number of the morbid operations proceeding in the animal body may be determined from the diseased phenomena presented by the urine; and not only the nature of the morbid actions themselves, but even their effects upon the tissues, as well as their degree and extent, ascertained. The urine, like all the fluids of the animal body, whether secretions or excretions, has a healthy condition or standard; and any deviation from this standard denotes a corresponding deviation in some one or more of the other functions. It is true, that these latter occasionally arise as mere temporary deviations from limited causes, and the alterations in the urine will be found to correspond in character, gradually disappearing upon the cessation of the causes whence they originated. A careful examination of the urine, therefore, is capable, in many cases, of throwing considerable light upon the nature, progress, and extent of other morbid affections; and this mode of investigation has these peculiar advantages, that it is easily conducted, and its indications are, in a great proportion of instances at least, almost unerring. Thus, in certain forms of dyspepsia, we may tell from some of the sensible qualities of the urine, and frequently convict a patient, apparently by a degree of

supernatural knowledge, of irregularities or violations of injunctions, which otherwise would never be acknowledged or confessed. As a necessary preliminary, however, it is essential to be acquainted with the properties and constituents of the urine in its normal condition.

The properties of the urine may be divided, as we have elsewhere * done those of matter in general, into the *sensible*, the *mechanical*, and the *chemical*. By sensible properties are to be understood those which are capable of affecting one or more of the *five external* senses. Consequently, these involve the agencies produced upon the *sight*, the *smell*, the *taste*, the auditory organs, and the sense of touch.† The last two may be almost omitted, as there are no properties belonging to the urine capable of particularly affecting the auditory functions, and but very rarely even the sense of touch. Consequently, the sensible properties may be arranged under the following heads:—viz., transparency, opacity, colour, &c.,—indeed all properties capable of impressions upon the visual organs. To the second belong all kinds of odour, and the changes effected in these by time or keeping. The taste will recognize the different impressions made upon the gustatory organs, by the predominance of special principles, and which are not only very varied, but even opposite, according to the greater or less prevalence of peculiar principles.

The mechanical properties may be stated as principally comprehending those depending upon the proportion which the aqueous principle, or water, bears to the others,—whether saline or animal,—dissolved in the urine. Hence, as in some measure an estimate of the above, the specific gravity of the urine is a most important phenomenon, and, in some instances, alone capable of affording an unerring diagnosis; as for example, in *diabetes*. Thus, if the specific gravity be steadily above 1·035, from that to 1·040, there can

* Chemical aphorisms.

† Unctuosity may be determined by the saponaceous feel.

hardly be a doubt of the existence of diabetes. In estimating the sp. gr. of urine, its temperature at the time of examination is of great importance, inasmuch as the sp. gr. of all bodies, and especially fluids, is much influenced by temperature. Thus, if we take the sp. gr. of water at 150° Fah., and of the same water cooled down to 40° Fah., we shall find the latter much higher than the former, although, from a peculiar law regulating the density of water, we shall find its gravity again diminish if cooled below this point, water having its density a *maximum* at 40° Fah. But this fact does not invalidate the rule laid down relative to the influence exerted by temperature upon the sp. gr. of the urine. The urine also when warm may hold a quantity of salts in solution, which it will deposit on cooling. At the temperature 98 Fah., at which it is when evacuated from the bladder, it is capable of holding in solution a large proportion of *urate* or *lithate* of ammonia, which separates and precipitates on cooling. The solution of this salt will raise the specific gravity, which, however, falls as the urine cools and the salt separates. Hence what apparently seems an anomaly, the sp. gr. of the urine when warm, occasionally exceeding that of the same specimen when it shall have arrived at the temperature of the surrounding medium. Hence then the necessity of connecting the temperature with the specific gravity.

By the chemical properties we understand the effects of chemical re-agents, which enable us to determine not only the nature, but even the relative proportions of the different constituents, and thus decide, not only whether the constituents be normal or abnormal, but also whether the proportion of a natural constituent be excessive or deficient in quantity. And this, as will appear hereafter, will be found an important guide, in renal or urinary *simulations*, in which several apparently very important and serious disorders are really irritations depending upon imperfect or perverted urination.

But now for the composition of the urine. The urine, as has been already stated, consists of a large proportion

of water, holding, when in health, a certain proportion of saline and animal principles in solution. The following analysis of Berzelius will afford some idea of the nature and complication of this fluid, even when in its normal condition. According to him, it consists of—

Water		933·00
Animal and destructible principles.	Urea	30·10
	Lithic Acid	1·00
	Free lactic acid (?) Lactate of Ammonia (?) and animal matters inseparable from the above (osmazone soluble in alcohol; extractive, soluble in water)	17·14
(Vesical) mucus		0·32
Alkaline and earthy salts	Sulphate of potass	3·71
	Sulphate of soda	3·16
	Phosphate of soda	2·94
	Phosphate of ammonia	1·65
	Muriate of soda (chloride of sodium ?)	4·45
	Muriate of ammonia (hydrochlorate)	1·50
	Earthy phosphates with a trace of fluate of lime (fluoride of calcium ?)	1·00
	Silex	·03

Such is the constitution of urine when the individual is in a state of health. Urine of this description will present the usual normal properties, or at least such trifling deviations as may be accounted for, without an appeal to disease. But in certain diseased conditions the urine is found to contain not only the above principles either in excess or in unnaturally diminished proportion, but in addition, principles wholly foreign to the normal constitution. The foreign or unnatural principles found in the urine, have been stated as follows :*

Separately or as blood	Albumen Fibrin Red particles	Of the chyle and blood.

* Prout.

Various acids, colouring matters, &c., either formed from, or accompanying the lithic acid.
Nitric acid.

Xanthine or Xanthic oxide.
Cystine or Cystic oxide.

Sugar.
Torulæ Diabeticæ.
Oxalic acid.
Carbonic acid.

Spermatozoa or Zoosperms. Benzoic, or Uro Benzoic Hippuric acids.
Prussian blue; Cyanourine; indigo.
Secretion of the prostate gland, &c.
Pus, and perhaps other matter.

From the above analysis of Berzelius we learn the constitution of human urine; and, consequently, any deviations from the normal proportion of the constituents, as well as the presence of foreign principles, become indications of disease. Urination, or the elaboration of the urine, is a process of the animal economy in which the functions of many and different organs are more or less immediately concerned; therefore it follows as an inference, strictly logical, that any deviation from the normal constitution of the urine must be attended with corresponding aberrations in the functions of the organs concerned; and these again, with corresponding changes in their tissues, however minute and inappreciable they may be. True, that temporary deviations, and to no great extent, are often present without any obvious accompaniments, and cease without farther inconvenience; and even when more permanent, they do not afford any immediate or direct clue to the more remote causes or consequences; still it must be admitted that in by far the greater proportion of instances, the conditions of the urine lead to much valuable and essential pathological knowledge.

The urine is voided from the body under two very

important relations; viz. immediately or very shortly after the ingestion of alimentary matter, whether food or drink. Now that passed soon after eating or drinking will differ very much in its properties from that passed when some time has intervened. The urine passed immediately after the copious ingestion of some mild or bland fluid will differ also very materially from that passed shortly after a meal, and before digestion has taken place. Dr. Prout notices two modifications, and terms them "urina potus," "urina sanguinis;" the first, "urine of the drink," very watery; the latter, that "of the blood," indicating urine more concentrated and more completely elaborated.

The ancients were not ignorant of the different conditions of urine passed under the circumstances alluded to. Thus we find Celsus mentioning the two modifications of "*crude*" and "*cocted*" urine; the former indicating actual digestion, the latter the completion of the process.* Hence, perhaps, urine might be considered under three different relations: 1. Urina potus; urine largely diluted from the copious ingestion of mild or bland fluids. 2. Urina cruda; urine passed after a meal, but before the digestion has been completed; and, lastly, Urina cocta, urine passed after the complete digestion of a meal, and when the assimilation of the alimentary principles, and the disintegration of the effete tissues have been perfected. The two last relations only are objects of importance in a pathological point of view. The urina cruda will afford, by its properties, data from which we may infer and determine certain aberrations in the functions of digestion, while the urina cocta will enable us to determine similar errors in the assimilative and absorbing functions. Consequently, to institute a perfect and complete examination, two at least, but perhaps the whole three specimens of urine, will be

* "Scire autem licet, integrum corpus esse cum quotidie mane urina alba, dein rufa est: *illud* concoquere, *hoc* concoxisse significat."—Cels. lib. i. cap. 2.

required, that is, the urina potus, or diluted urine; the crude and cocted; and the various properties already mentioned, namely, the sensible, the mechanical, and the chemical, should be carefully observed. And first, the sensible properties.

Urine, when healthy and recently voided, and still warm, presents a light amber colour, and is perfectly transparent; it has a peculiar odour, somewhat aromatic, and in a degree resembling that of violets. Its taste, saline, bitter, and rather disagreeable. Its touch is never unctuous or greasy;* unless from the intermixture of some fatty matter derived from either the secreting or containing organs. Any deviation, therefore, from the above properties, as deeper colour, cloudiness, opacity, &c., should be noted, and the causes investigated. Likewise the changes effected by time should be attended to. For this purpose the specimens in different vials, containing from an ounce to an ounce and a half each, should be set aside for from twenty-four to thirty-six hours, and the changes, in appearance, &c. examined,—as whether they become cloudy or opalescent; whether an ammoniacal odour, &c. be evolved, and indeed all changes in the sensible characters. The mixed urines of the twenty-four hours should be examined in a similar manner.

The mechanical properties include both quantity and specific gravity. The specific gravity so greatly depends (*cœt. par.*) upon quantity and temperature, that it is necessary, where accuracy is of importance, to note these three in connection with each other. The specific gravity of a fluid will vary according to the nature and proportion of such principles as it may hold in solution, sp. gr. being nothing more than the difference of density in the fluid compared with that of distilled water. This relation may be determined or computed by various

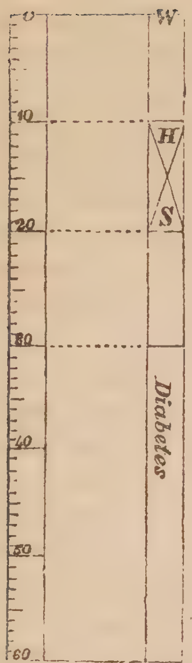
* Some urine was once submitted to me at the London Dispensary which felt quite unctuous, owing to a large quantity of carb. potas. introduced either accidentally or by design.

methods. We fill a vessel, of convenient form, a bottle for example, capable of containing a known weight of distilled water, with the urine or fluid the sp. gr. of which we are desirous of determining; on weighing, we at once determine the gravity. The gr. of distilled water is arbitrary and fixed at 1·000, consequently the weight $\div$ 1·000 = sp. gr. Thus let the weight of the fluid be 2·500, while the same measure of distilled water weighs only 1.000, then 2·500 $\div$ 1·000 = 2·5 the sp. gr. required.

But a more convenient instrument, and still sufficiently accurate for the purpose, is the little instrument contrived by Dr. Prout, called the Urinometer. It is constructed of glass, in form similar to an hydrometer. The stem is graduated on one side from 0 to 60; 0 gives the gravity of distilled water, and should be read or understood as 1·000; the intermediate numbers, therefore, will be 1·010,1·020,1·030, &c. To determine the sp. gr. the instrument, perfectly clean, and free from grease or air bubbles, should be gently and carefully placed in the urine, and allowed to remain for some seconds, till it becomes perfectly stationary. The portion of the stem above the fluid will indicate the sp. gr. For instance, if the surface of the fluid coincide with any number, as 35, 40, &c. on the stem, such number will give the sp. gr. compared with water taken as 1·000, and is read thus, 1·035, 1·040, &c. The specific gr. bottle is the most accurate.

To facilitate its use, the other side of the stem is marked to indicate the different states of the urine corresponding to the sp. gr.: thus—as shown in the annexed figure, W or 0 is the sp. gr. of distilled water; the blank space from W to the first horizontal line comprises ten divisions of the scale. Abundant urine of this sp. gr. is frequently alkaline, or speedily becomes so, and denotes tendency to deposit the earthy phosphates.

The space between this and the next horizontal line is divided by two diagonal lines crossing each other into two triangular spaces, the triangles being con-



nected by their vertices somewhat in the form of the letter X; the square includes the range from 10 to 20; the upper triangle is marked with H, and includes the range of the urine of health when the quantity and appearance are natural; the lower is marked S, and denotes, when the urine is copious, pale-coloured, and watery, spasm and nervous irritability, hysteria, &c. The space from 20 to 30 is included within two horizontal lines, and infers excess of urea. Any sp. gr. beyond this almost certainly denotes diabetes, and is so marked. But the other circumstances which qualify the above signs will be explained in a subsequent part.

The sp. gr. affords some estimate of the quantity of saline or other principles held in solution by the urine. But as the temperature influences the sp. gr., this should always be determined by means of the thermometer. An elevated temperature, in many instances, reduces the sp. gr. of a fluid or solution; but the urine frequently abounds in saline principles, &c., soluble while the urine is hot, but separating as it cools. In such cases, provided the urinometer be used for the purpose, the sp. gr. should be taken while the urine is yet hot, and again when it shall have deposited its insoluble salts,* and it will often happen that the gravity under these circumstances will differ by some decimals. Therefore the thermometer is essential where accuracy and precision are required.

Although the chemical constitution of the urine, and the nature of its constituents can be determined only by chemical analysis, the proportion of its solids to the

* These are mostly the lithate of ammonia, and the other alkaline lithates, as will be explained hereafter.

water may be determined with sufficient accuracy for most practical purposes by means of its specific gravity. Henry, Becquerel, and Christison, have each endeavoured to determine the correspondence between the sp. gr. of the urine and the solid contents of 1000 grains of the fluid. The solid contents of 1000 grains according to these authorities may be estimated for every unit in the decimals of its gravity, at :—

according to	Dr. Henry	2·58
,,	Becquerel	1·65
,,	Christison	2·33

Therefore if the excess of the density of the urine over that of distilled water, taken as unity or 1·000, be multiplied by either one of these numbers, it will give the solid contents in 1000 grains of the urine according to the respective authorities. Christison's estimate is looked upon as the most correct, and is adopted in this place. As an exemplification of the formula, let us represent the excess of the density of the urine compared with water as 1·000 by D, then D × 2·33 will give the solid contents in 1000 grains of such urine. For example, let us suppose the specimen to have a sp. gr. of 1·020 × 2·33 = 46·60 for 20 the units multiplied by 2·33 gives 46·60, or cutting off the right hand cypher, as of no value, 46·6 the weight of the solids in grains. That we may cut off the right hand *cypher* as of no value will appear from the illustration annexed; thus :—46·60 hundredths are of the same value precisely as 46·6 tenths. Having thus determined the weight of the solids, we readily determine the amount of the water. We have only to subtract the weight of the solids 46·6 from the gross weight, and the remainder will give the weight of the watery portion 1000—46·6 = 953·4 grains the amount of water in 1000 grains of urine of sp. gr. 1·020. It is evident that by ascertaining the weight of urine passed in 24 hours, we can readily compute the amount of solid matter evacuated in that time through this excretion.

But although the formula as above answers tolerably

well for most practical purposes, and where expedition is necessary, it is not unerring; and where great accuracy is required, a given weight of urine, 1000 grains for instance, should be evaporated in a water bath, or hot air chamber, till it ceases to lose weight. The weight of the residue will be the amount of the solids; and the weight of the water is then readily ascertained as above.

If we compare the result of Berzelius' analysis with the composition deducible from any of the formulæ mentioned, it will be evident that his analysis is far above the estimate of health. Given the solid contents of a certain weight of urine, we may, by a sort of inversion of the formula for ascertaining the amount of the solids from the sp. gr., determine the sp. gr. of such urine. Berzelius' analysis gives the composition of 1000 parts of the specimen analysed as consisting of 933 of water and 67 of solids. We have only to *divide* the solids by 2·33 and add to the quotient the sp. gr. of distilled water, and we obtain the sp. gr. of the specimen. Thus if we divide 67 by 2·33 we obtain the density of Berzelius' specimen. For instance $67 \div 2{\cdot}33 + 1000 =$ very nearly 1·030 which according to Christison's formula must have been the sp. gr. of that specimen; but upon Becquerel's estimate the density must have exceeded 1·040, a gravity wholly inconsistent with natural or healthy urination.

It may be further observed, that the urine, as has been proved by Liebig, contains no lactic acid whatever, either free or combined,* but that it contains *hippuric* acid instead, and in the proportion nearly of the *uric* acid. Therefore the following may be considered as a much nearer approximation to the real constitution of the urine.

Water . . .	953·400
Urea . . .	19·889

* I have satisfied myself of the correctness of Liebig's statements upon this subject.

Uric, or Lithic acid . . .	0·653
Azotized body of Pettenkofer .	5·000
Hippuric acid	0·481
Colouring matters: Extractive, and hydrochlorate of ammonia not separable from each other . . .	9·206
Fixed Salts consisting of { Chlorine, Sulphates, Phosphates, Calcium, Sodium, Potash, Soda, Lime, Magnesia . . .	11·371
	1000·000

From the above we find that the solids amount to somewhere about 46·6, and the water to 953·4 in the thousand parts, and unquestionably this is much nearer the truth.

Among the mechanical properties may be ranked the quantity. Scanty urine is generally of high specific gravity, and (*cæt. par.*) denotes a diminished secretion of watery fluid; whereas a copious or abundant flow of urine, under similar circumstances, indicates an increased secretion of the watery portion; and a high or low specific gravity in such cases does not infer any absolute or positive excess or diminution of the saline or heavier principles. But when the sp. gr. is high, and the urine of the ordinary quantity, or even exceeding this, we may infer either an excess of the normal constituents, or the presence of even foreign principles, as, for instance, sugar.

The ordinary temperature of healthy urine may be estimated at from 92° to 98° Fahr; the sp. gr. between 1·012 and 1·017; and the quantity at between 40 and 50 ounces in twenty-four hours. The measurement of the quantity must mostly be left to the patients themselves; but the medical attendant should fully note all remarkable deviations from the standard of health.

The next mode of examination is the chemical. By this method we determine the relative proportions of the constituents; and also whether the urine is vitiated by

the presence of foreign principles. The first thing to be ascertained is, whether the urine presents any peculiar re-agency of either an acidulous or an alkaline nature. This is best effected by immersing a small slip of litmus and turmeric paper into the urine. If it speedily and deeply reddens the litmus, the urine is acidulous;* but if it reddens turmeric, the urine is strongly alkaline.† These reactions are of very great importance, as frequently indicating a tendency to particular kinds of stone or gravel, or as denoting peculiar organic affections of the bladder.

We shall now take the principles in order. The normal quantity of water is to be determined by the quantity passed in a given time, and the sp. gr. If not more than forty ounces of the usual sp. gr. be passed in twenty-four hours, we may conclude the watery portion to be in the normal proportion; and deviations from the above will be readily understood from what has been already stated.

Urea.—The normal proportion of this principle is about twenty parts in one-thousand of urine. But this principle may be unnaturally increased or diminished. When in the normal proportion, no crystallization takes place on the addition of nitric acid, even after a considerable interval, but when urea is in excess, crystallization takes place very speedily after the addition of nitric acid; and the interval between the addition and the crystallization may be taken as a tolerably fair index of the excess of urea. To examine for this principle, a small quantity of urine should be placed in one of the glass capsules, and with the dropping tube nearly an equal quantity of nitric acid should be allowed to trickle along the concave surface of the capsule, so as to pass under and float the urine upon its surface. In summer, or in a warm room, the capsule should be placed upon

* Healthy urine does and ought to redden litmus, in virtue of the superphosphate of ammonia, lime, &c., which it holds in solution.

ice. If urea be present in excess, crystallization will take place more or less speedily in proportion to the excess. Urine abounding in urea has generally a high sp. gr., from 1·020 to 1·030. Hence the sp. gr. is frequently an indication of an excess of urea.

Urea may be deficient, and this is frequently associated with the presence of foreign matters, especially sugar, in the urine. If the watery portion of the urine be increased, the quantity of urea, as well as of the other principles, will be relatively, not positively, reduced. Such cases will be readily distinguished by the reduced sp. gr. and increased quantity of the urine.

The readiest method of estimating a real deficiency of urea is either to evaporate the urine at a gentle heat to one-half or two-thirds, then, the quantity of water being reduced, if no crystallization takes place on the addition of nitric acid, urea may be considered as deficient.

To estimate the urea with certainty, a given weight of urine—1000 grs. for instance—should be evaporated down to one-third its bulk. To this, cooled down by placing the capsule on pounded ice, add nearly its bulk of nitric acid,* crystallization takes place, and nitrate of urea is formed. The whole should now be thrown on a filter, and some snow or finely powdered ice placed upon the nitrate. The ice melting, passes through the filter at the temperature of 32° Fahr., and washes the salt without dissolving any. The washing completed, the nitrate is to be dried and weighed.

Urea consists of N_2 C_2 H_4 O_2, consequently its equivalent is 60. The nitrate usually crystallizes with one eq. of water; consequently its eq. by weight will be—

$$\left.\begin{array}{lr} \text{One eq. of urea} \;\ldots\ldots & 60 \\ \text{,,} \quad \text{nitric acid} \;\ldots & 54 \\ \text{,,} \quad \text{water} \;\ldots & 9 \end{array}\right\} 123$$

* Care should be taken that the nitric acid is perfectly free from any admixture with nitrous acid, or nitrous gas, which decompose urea, and would thus lead to error.

Therefore, as every 123 parts of crystallized nitrate represent 60 of urea, from these data it is easy to estimate any other proportions.

Lactic acid, according to Liebig, does not exist in the urine, and therefore will not require any particular remark.

There are various ways of obtaining lactic acid, but as they involve complex chemical details, wholly inapplicable to ordinary investigation, I shall refer to chemical works, or to my Lectures on the Urinary System, published in 1838-39, in the *Medical Gazette*. Dr. Prout considers urea and lactic acid as derived principally from the gelatinous tissues;* hence he says their examination "will often furnish a clue to diseased operations, which would be sought for in vain through any other channel." †

Uric, or *Lithic acid*, always exists in healthy urine, in combination with ammonia, by which it is held in solution. Its affinities are so weak that it is separated by every other, even the carbonic acid. Hence, if any dilute acid be added even to healthy urine, the lithic acid separates mostly in the crystallized form. An acidulous (naturally) state of the urine may be frequently determined by allowing it to remain quiescent for a time, when the lithic acid will separate in the crystallized form by the natural re-agency of its own acidulous principles. This is a formidable state of things.

Lithic acid sometimes abounds to a great extent in the urine, but so combined as to be held in solution. Notwithstanding the very great insolubility of lithic acid, —requiring nearly 10,000 parts of water for solution, ‡ —the lithate of ammonia is comparatively very soluble. Lithate of ammonia also is much more soluble in hot than in cold menstruums. Hence urine surcharged with

* Dr. Prout does not agree fully in the theory that gelatine is not a natural but an artificial compound.

† Page 211.

‡ Liebig asserts that it requires 15,000 times its weight of water for solution.

lithate of ammonia will preserve its transparency while hot—the lithate being completely soluble at this temperature, but becomes turbid on cooling, owing to the lithate becoming insoluble, and, consequently, separating. We recognize therefore the alkaline lithates by this peculiar property. The urine when first passed is perfectly transparent, and free from cloud or sediment. As it cools it becomes cloudy, and ultimately the precipitated lithate of ammonia subsides, leaving the urine clear and cloudless above. A portion of the urine agitated so as to diffuse and suspend the lithate, heated in a capsule or test tube over the spirit-lamp, gradually becomes transparent, and the whole of the salt is dissolved, separating again as the urine cools. Further, the lithic acid may be verified by the means to be detailed under the head of lithic acid gravel, or calculi. Indeed the lithic acid may be separated in its characteristic form by the addition of any dilute acid at the temperature of solution. The above properties will distinguish these sediments from the phosphates which sometimes subside from diffusion through the urine.

As to the mode in which lithic acid exists in urine, Liebig asserts that the urine contains two organic acids, and that the acidity depends not upon any free acid, but the acidulous salts which it contains. In support of his views he gives the following formula for an artificial urine. He says, if forty grains of *tribasic* phosphate of soda; (consisting of $P\,O_5 + 2\,N^a\,O + H\,O$) or one of phosphoric acid, two of soda and one of water; or ninety grains of the crystallized, same composition as above $+ 24$ Aq. be dissolved in one pound of water, the solution will have an alkaline re-action. If, however, *lithic* and *hippuric* acids in the proportion of *fifteen* grains *each* be added, both acids dissolve, and a strong acidulous reaction will be given to the solution. The solution thus prepared does not deposit even a trace of lithic acid, so long as the temperature does not fall below 38° or 37° cent. (=100° ·4 and 98° ·6 Fahr.), about the temperature of the blood, or of the urine when first

voided; nor does any sediment appear till several hours after complete refrigeration. At last, however, a deposit subsides, consisting of lithic acid in combination with *soda.* "This sediment," says Liebig, "is of an analogous form to that deposited by natural urine after standing at rest for a long time. Upon collecting this sediment, in one of my experiments, after the lapse of twenty-four hours, I found that it weighed $7\frac{1}{2}$ grains, so that there remained still in solution $22\frac{1}{2}$ grains of the organic acids. Dilute mineral acids produce immediately in the fluid filtered off from the sediment a precipitate of uric (lithic) acid." *

Lithic acid has a composition represented by the formula ($N_4\ C_{10}\ H_4\ O_6$ eq. 168). The proportion of lithic acid may be readily determined. A determined weight from the mixed micturitions of the previous twenty-four hours should be warmed, and then poured into a jar in which from half a drachm to a drachm of pure hydrochloric acid had been previously placed. The capsule should be washed out with a little warm distilled water,† the washings being added to the acidulated urine. The whole should be set aside and put under a jar, or covered with paper to keep off the dust, &c. After a time the lithic acid will be found partly subsided, partly as a pellicle on the surface, and partly adhering to the sides of the vessel. The acid should be detached, washed with diluted hydrochloric acid, collected, dried, and weighed. By a very simple calculation we can now estimate the quantity of lithic acid voided in twenty-four hours.

Urine abounding in lithic acid is mostly scanty, high-coloured, and of considerable sp. gr. It is in general associated with the phlogistic diathesis, or inflammatory state of the system. Hence, bleeding, mercurials, and other antiphlogistics are indicated in such cases; but such

* Lancet, Vol. i. Nos. 11, 12.

† If there be mucus albumen or such principles, the urine should be heated, filtered, and the examination made upon a portion of the filtrate.

considerations are foreign to the objects of this summary.

The lithates are deposited under three different aspects, namely, yellow, or cream-coloured, the red, and the pink. Dr. Prout looks upon the lithic compounds as derived from the albuminous principles of the chyle and blood, as well as from the decomposition of the albuminous textures themselves. Hence, a knowledge of their nature, independently of the information they afford relative to the diseased states of the urine, frequently throws considerable light upon the derangements of the digestive process, and their specific nature.

Colouring matter. The urine naturally contains colouring principles, and Dr. Prout maintains that there are two distinct varieties. If the colouring principles be deficient, it denotes derangement either of the primary or secondary assimilation. In over-abundance it infers a phlogistic condition. To decide, a small portion of the urine should be boiled in a test-tube. If about one fourth the bulk of hydro-chloric acid be now added, the colouring matter is rendered evident by the deep hue given to the pigment.

Hippuric acid. This acid, known to be a constituent of the urine of the horse, &c., has been shewn by Liebig to exist in the urine of man. If the urine be evaporated down to a very small bulk, and then heated with hydro-chloric acid, the lithic and hippuric acids precipitate; the urine should be poured off; the acids washed with a small quantity of ice cold water. If boiled in alcohol, the *hippuric* acid is dissolved, and may then be separated from the lithic by filtration. The acid is obtained from the filtrate by evaporation.

Mucus.—The bladder and urinary organs are lined, like many others, with a peculiar membrane, named mucous, which secretes a peculiar principle termed mucus, and which serves to protect the part from the irritant action of the fluids either contained or transmitted. This mucus in the healthy state is so small in quantity, that it has little or no effect upon the appearance of the urine. After rest, however, it is often

observed to have subsided, either occupying the bottom of the vessel, or remaining suspended as a mass at different depths. If the urine be thrown on a filter, the mucus, after the urine has passed through, will be found like a coat of varnish upon the filter. It is not an object of any importance unless it have become excessive in quantity, or vitiated in quality—circumstances to be noted hereafter.

Epithelium.—The structure of the mucous membrane consists of an interlacement of fibres, on which, in some parts, a layer of very minute perpendicular cylinders rest, and in which the numerous mucous follicles are seated. The mucous membrane of the urinary, as well as of some other passages, are covered by an *epithelium*, the minute portions of which are arranged side by side, somewhat like a pavement. The particles, each of which contains a nucleus, are constantly separating and thrown off. They have the appearance of thin scales. The mucous lining of the urethra is furnished with an epithelium, which is incessantly throwing off these minuter scales, or squamulæ, nor are they difficult to distinguish with the assistance of the microscope. Vigla has seen them in great abundance; they are small and roundish, but still not regular; in the middle, or sometimes at the sides, they appear dark, and mostly somewhat elevated. Under ordinary circumstances, and in the healthy state, there is nothing very remarkable in the epithelium; but in certain cases of irritation of the mucous lining, they are thrown off in such large quantity, that subsiding, soon after voiding the urine, in extraordinary abundance, they are commonly mistaken for the mucous cloud in large excess, of healthy urine. Thus we may often detect irritation, or at least a state approaching irritation, in the mucous membrane, by examining the cloudy deposit, long before it is indicated by the ordinary symptoms.

The next order of principles is of the mineral character, and comprehends the alkaline and earthy salts; and, first, of the alkalies. The two fixed alkalies are mostly

combined with the sulphuric, phosphoric acids, and chlorine. They may be either in excess or deficient, and in consequence give rise to peculiar diseases.

Potass—Is stated by Berzelius to exist in the urine, as sulphate, in the ratio of 3·71 to 1000.* Potass and soda both, when in excess, however, appear to exist rather as bicarbonates; for the urine in which they so exist effervesces, giving off carbonic acid, by mere agitation, by heat, but especially on the addition of any of the stronger acids, as the acetic, hydro-chloric, &c., diluted.

Sodium—Exists in still greater proportion, both as phosphate of soda and chloride of sodium, the ratio being $2·94+4·45=7·39 : 1000$. To determine the quantity of the two fixed alkalies, the best plan is to convert them into *chlorides*, by a solution of neutral chloride of barium. Insoluble salts of baryta will be formed, from which the alkaline chlorides may be separated by mere decanting or filtration. On concentrating the solution, the potass may be precipitated by excess of tartaric acid, and its quantity be thus estimated. The chloride of sodium may be obtained by subsequent evaporation.

When greater accuracy is necessary, the compound solution of the mixed chlorides may be evaporated, and then exposed to the action of spirits of wine containing about 60 per cent. of alcohol. The chloride of sodium will be dissolved out, and its quantity estimated by evaporation; the chloride of potassium may be dissolved and precipitated by tartaric acid as before.

In estimating the quantities of constituents, volumes may be made to represent weights, by processes easily understood; but as such minute precision is seldom necessary in a pathological point of view, morbid excess can be readily determined by the evidence of the senses upon the products from any given volume.

* As Berzelius' estimate has been shown to be about one-third over that of natural urine, these estimates should be reduced each about a third, which will then be near the reality.

Ammonia—Exists naturally in the urine in combination with phosphoric, and also with hydro-chloric acid. The proportions 3·15 : 1000. Sometimes, however, its quantity is morbidly increased, and it enters into the formation of some species of calculi. It also is found as carbonate, derived, in fact, from the decomposition of urea, which is readily converted into carbonate of ammonia, by the fixed alkalies which are found in diseased mucus or by pus.

Alkaline urine generally indicates a tendency to deposit the phosphates, which it does by neutralizing the excess of phosphoric acid by which the earths are rendered soluble. It also indicates frequently a diseased condition of bladder, at least of its mucous coat. When a large quantity of mucus is secreted, and this vitiated in quality, the urine is often highly alkaline when voided, turning turmeric deeply brown; but should it not be so, or only neutral, it very speedily becomes alkaline, exhales a strong ammoniacal odour, and very soon becomes putrid. The sp. gr. of such urine is also very various. The urine is often very abundant; opalescent, or sometimes clear, like water. In some cases the sp. gr. hardly exceeds that of distilled water; in other cases it amounts to 1·020 or 1·030. Such conditions, generally speaking, contraindicate the use of mercury; but for more complete information I must refer to Dr. Prout's work, or to my own Lectures, published in the *Medical Gazette*.

Lime—Forms a constituent of healthy urine, in which it is held in solution, not only by phosphoric acid in excess, but still farther by the alkaline chlorides and carbonates, and hydro-chlorate of ammonia. The normal proportion of phosphate is one part, or rather from ·3 to ·4 of a part in 1000. Sometimes, however, the phosphate of lime is much increased, or at least the earthy base, when it is found also in combination with other acids, especially the oxalic. Phosphate of lime often forms prostatal concretions, and is also occasionally

thrown off, together with the carbonate, from the mucous coating of the bladder.

The quantity of lime in solution may be rendered evident by adding to a portion of the urine a little acetic acid, and afterwards the oxalate of ammonia. The oxalic acid will precipitate the lime as oxalate of lime, and the proportion may be thus readily inferred, by comparing the bulk of the precipitate with the volume of urine used; or more accurately, by collecting, drying, and weighing the oxalate, from which the weight of the lime can be easily deduced. The addition of acetic acid previously precipitates any lithic acid, if it exist, and the oxalate of ammonia should be added to the decanted or filtered portions. The oxalate of lime precipitates as a white flocculent powder, which by boiling becomes heavy and granular.

Magnesia—When present, precipitates with the oxalic acid as oxalate of magnesia; but if there be much hydrochlorate of ammonia in the solution, the magnesia will not precipitate, because it is soluble in hydro-chlorate of ammonia. We therefore filter from the oxalate of lime, and precipitate the filtered liquor by carbonate of potass, or ammonia, and boiling; carbonate or some other mode of magnesia will be formed, and will precipitate. These precipitates may be ignited, and the quantity of pure earths thus accurately ascertained; but it is seldom necessary, for practical purposes, to proceed so far.

Tolerably fair estimates of the quantity of earthy bases may be more hastily effected, by adding liquor potassæ, which will precipitate them as neutral phosphates; or if liquor ammoniæ be added, the ammonio, or the mixed and fusible-phosphates, will be thrown down, which, fused before the blow-pipe, will, by the weight of the bead compared with that of the urine from which it was obtained, enable us to judge with quite enough precision of the quantity of the earthy bases present in the specimen.

Acids.—With respect to the mineral acids naturally

existing in the urine, they are so neutralized or combined, that they can exert no chemical reagency upon the other urinary constituents: but should they be secreted in excess, they will give rise to decompositions, and the consequent formation of new and dangerous products. The excess of the stronger acids act by depriving the weaker of their bases, and combining with them themselves. Thus, for instance, we may suppose the hydro-chloric to liberate the uric, and by taking from it its base, sets it free; and this thus set free being very insoluble, either assumes the crystalline form, is expelled as gravel, or forms a nucleus for future depositions. The sulphuric and hydro-chloric acids are very easily estimated, because they form compounds, which are insoluble, and their weights are easily ascertained.

Hydro-chloric Acid—Exists combined with ammonia in the proportion of 1·5 of the salt to 1000 of urine. We also find 4·45 of chloride of sodium in the same quantity, making altogether 5·95, or nearly six parts of the saline compounds of chlorine in 1000 parts of urine. To separate the hydro-chloric acid, all that is necessary is to add nitrate of silver, when we shall precipitate the hydro-chloric acid as an insoluble chloride. To insure complete accuracy, however, some precautions are necessary. If the urine be alkaline, especially ammoniacal, acetic, or perhaps preferably nitric acid in slight excess should be added; otherwise the ammonia would hold the chloride in solution. A little organic matter is precipitated by the oxide of silver, but this is easily got rid of by heating in a Berlin crucible, and treating the residue with a little nitric acid, and washing in distilled water. The insoluble residue will be chloride of silver, and from its weight that of the chlorine or of muriatic acid can be deduced.

Sulphuric Acid—May be precipitated by acidulous nitrate of baryta; an insoluble sulphate of the earth will fall down, which may be washed with diluted nitric acid, and afterwards exposed to heat. The weight of

the dried mass will afford the means of determining the precise quantity of sulphuric acid.

The acids are of importance, inasmuch as, if free, they cause a liberation of lithic acid; and indeed a predominance of some of the acids indicates particular diatheses. Thus the predominance of the *hydro-chloric acid* seems in general to denote a *phlogistic* or *inflammatory* state of system, while that of the *lactic* marks rather a state of *irritation*.*

Acidulous urine, with a tendency to deposit lithic acid, is known by its peculiar effect upon litmus paper, being also perfectly transparent and free from cloud or sediment, of a bright copper colour, and after a time it deposits lithic acid in the crystalline form. The sp. gr. is mostly high, above 1·020.

Foreign Principles — Principally consist of organic matters, and they may be considered in the order of enumeration.

Albumen—Is sometimes found in considerable quantity in the urine, insomuch that on being heated it forms almost a solid opaque mass. The addition of nitric acid likewise causes coagulation, especially if assisted by the application of heat. But urine abounding in chyle also coagulates under similar circumstances. When the urine contains coagulable matter in small quantity, the best test is the prussiate—ferro-cyanide of potassium. The urine should be rendered slightly acidulous by a drop or two of acetic acid, and the solution of the prussiate then added. If the urine contain either serum or chyle, a cloud more or less dense and opaque will speedily form and gradually subside.

Serum and chyle seem to coagulate with different degrees of density. When albumen is the coagulable matter, the mass is more solid and tough, whereas chyle affords a more *curdy* light, and, as it were, flocculent precipitate.

An albuminous state frequently prevails after some

* Prout, p. 72.

of the exanthemata, especially scarlet fever. It also prevails in some forms of dropsy, and denotes granular degeneration of the kidneys. Indeed chylo-albuminous urine is of great moment, inasmuch as denoting certain morbid states of kidney, which it is of importance to recognize.*

Fibrin, *Xanthic*, and *Cystic* oxides, will be considered under the head of calculous concretions. Fibrin sometimes is passed by the kidneys, and moulded in the ureters, so as to assume the appearance of small threads.

Blood.—Bloody urine is necessarily albuminous, but the converse of the proposition does not hold good. When blood is abundant, and its characters not masked, it may be readily distinguished. But there are many appearances assumed by the urine, so closely resembling a bloody condition of urine as to readily deceive.† No urine should be considered bloody unless we can detect hæmatosine. The composition of this principle, according to Mulder, is represented by the formula $N_3\ C_{44}\ H_{22}\ O_6 + Fe$. The iron in hæmatosine amounts to from 6·64 to 6·66 per cent.; and it is upon the iron that I should rely in doubtful or difficult cases. We proceed as follows:—

Boil the urine so as to coagulate everything coagulable by heat and filter. Throw the filter with its contents into a crucible, mix with some black flux, and expose to a red heat for some time. If the urine contained blood, the residue after ignition will be found in part attractable by the magnet. It may now be washed with water, which will carry off the alkali of the flux, and the residue treated with hydro-chloric acid will be found to afford a solution which, when filtered, will be perfectly clear, transparent, and almost colourless, if the iron be in small quantity. But on adding a solution of *red* prussiate of potass, (Ferridcyanide of potassium,) a

* See Prout, Christison, Bright, &c.

† See an article on Hæmaturia, &c., by the author, in the *Medical Times*, July 21, 1849, p. 51.

beautiful azure blue colour results from the formation of prussian blue.*

Nitric acid is not of special importance, and therefore the reader is referred to the author's lectures published in the *Medical Gazette.*

Sugar—Is a principle found in certain diseased states of urine, and especially in diabetes, to which condition the term should be confined. Sugar, when in large proportion, is known by the sweet taste which it gives to the urine. The sp. gr. of saccharine urine is for the most part high, above 1·030.

When sugar is in very small quantity, or that its sensible properties—the sweet taste for instance—are masked by other matters, then some manipulation becomes necessary to determine the presence or absence of this principle. The urine may be evaporated to dryness, and the extract hardened by continued desiccation. The hard mass treated first with cold alcohol, and afterwards with boiling, which last dissolves the sugar, on evaporation will yield solid sugar.

Diabetic urine also undergoes vinous fermentation; if therefore a little yeast be added to diabetic urine, and the temperature favourable, carbonic acid may be disengaged, and alcohol may be distilled or obtained by other well-known processes from the residue. If the carbonic acid be collected in a graduated jar, the cubic volume may be ascertained, from which the weight of the sugar can be determined. Each cubic inch of gas is equivalent to about one grain of sugar.

Runge proposes the following, as both precise and delicate. The suspected urine is to be evaporated at a very moderate heat † to dryness; upon the dry residue, in a porcelain dish or plate, drop sulphuric acid diluted with from six to eight parts of water. If sugar be present, the mass acquires a dark or even black colour.

* For greater detail the reader is referred to the author's paper in the *Medical Times*, already referred to.

† By the sand-bath apparatus, for instance.

Previously, however, it will be proper to free the specimen from organic matter by adding a solution of acetate of lead, filtering and precipitating the excess of lead by hydro-sulphuric acid gas,* and then boiling. The sulphuric acid may now be applied, as above directed, with much greater certainty.† A very inefficient test.

The carbon of sugar may be very readily and directly changed into oxalic acid by the action of permanganate of potass. If, for instance, we act upon an equivalent of sugar by six of permanganate of potass, we shall obtain twelve of peroxide of manganese, nine of water, and six of oxalate of potass. Thus, one of sugar $=C_{12}\ H_9\ O_9$ and $6\ (Mn_2\ O_7+KO)=12\ (Mn\ O_2)+9\ H\ O+6\ (C_2\ O_3+K\ O)$. The oxalic acid may afterwards be separated by a soluble salt of lime.

Since the former edition the following have been proposed:—

Trommer's Test. Add to the urine in a test-tube a few drops of a solution of sulphate of copper; a sort of bluish haze takes place, probably from precipitation of phosphate of copper. Solution of potass is next added, till the whole becomes strongly alkaline. The copper first thrown down, with that subsequently precipitated by the potass, is, if sugar be present, re-dissolved by the excess of alkali; the fluid acquiring a sort of purple or azure blue colour, resembling that of ammoniuret of copper. The mixture is to be gradually heated to the boiling point. As the fluid approaches this point, if sugar be present, it will assume an orange red colour, and on standing, a deposit of *red* or *suboxide* of copper will subside. But if no sugar be present, the copper

* For more complex modes, the reader is referred to my lectures.

† To pass a current of sulphuretted hydrogen, pour a sufficient quantity of the mixture of iron and sulphur from the bottle into the two-necked bottle, add as much water as will form a stiffish paste, and set by in a warm place for two hours. If one part of sulphuric acid, diluted with four or five of water, be poured upon the mass, sulphuretted hydrogen will be generated in abundance, and by the conducting tube may be passed through any fluid.

separates as the black oxide. This test is founded upon the reducing agency of the sugar at a high temperature upon certain of the metallic oxides.*

To determine the nature of the precipitate, the suboxide treated with ammonia gives at first a *colourless* solution, but absorbing oxygen, in a few seconds becomes a deep blue. Capezzuoli proposes a modification —unimportant.

Moore's Test. Boil the suspected urine in a test-tube with nearly an equal bulk of liquor potassæ, perfectly free from any contamination with lead. If sugar be present the liquid assumes the colour of ale, passing on to an orange brown, according to the proportion of sugar. This test is a very good one, for urine free from sugar is generally rendered white by potass. The change of colour effected by the alkali probably depends upon the formation of sacchulmine or sacchulmic acid.

Lowig's Test. Evaporate the urine to the consistence of a syrup, heat with alcohol, and add alcoholic solution of potass. If sugar were present, a white precipitate of sugar and potass subsides. Wash this in alcohol and dissolve in distilled water. A saccharine solution will be formed, which may be examined by any of the processes, and the amount of sugar, if required, easily determined.

The plan proposed in my lectures † is to free the urine by a soluble salt of lead; filter and remove the excess of lead from the filtered urine by a current of hydrosulphuric acid gas. Evaporate and dissolve out any urea by cold alcohol. Diluted alcohol boiled on the residue dissolves the sugar, which on evaporation will be deposited in crystals. For ordinary practice Trommer's and Moore's tests are the most convenient, and, confirming each other, are but little subject to fallacy.

Diabetic sugar is identical in composition with that of grapes; its formula being $C_{12}\ H_{14}\ O_{14}$, and distilled with nitric acid yields oxalic acid $= C\ O + C\ O_2$ or $C_2\ O_3$.

* Author's Lectures, Medical Gazette.

† Medical Gazette for 1838-1839.

These two gases in equal volumes united with water form oxalic acid.

Oxalic acid has not been found dissolved in the urine; and indeed this is consistent with its known reagencies, as it would be precipitated by the lime found in healthy urine. In certain morbid states of system oxalic acid is formed, and uniting with lime, gives rise to those urinary concretions named "mulberry calculi." It will be unnecessary to consider this principle at present, as we shall have to detail the characters of the oxalate of lime calculus at a future period.

It may, however, be observed, that Dr. Bird has discovered oxalate of lime in very minute octohedral crystals in urine, and considers such urine as characterising certain forms of dyspeptic disease. The oxalate is discoverable principally by microscopic observation.

Carbonic acid.—This acid is often found in the urine, both in excess and in combination with the alkalies. It is readily disengaged, either by heating the urine or by adding a stronger acid. It may be separated, and received over water or mercury. By its excess it often holds the otherwise insoluble salts of lime in solution; and hence such urine becomes turbid on being heated, in consequence of the escape of the carbonic acid, and the deposition of the carbonate and phosphate of lime, &c., which it held in solution. This acid also enters into combination with the lime, forming solid urinary concretions of the carbonate of this earth. Carbonate of magnesia is sometimes held in solution by the urine. Such urine becomes turbid on being heated. Turbidity under an elevated temperature may arise from albumen, from deposit of phosphates, or from carbonate of magnesia. If from albumen, nitric acid, though at first it may dissolve the albumen, added in larger quantity it will re-precipitate the albumen; but phosphatic urine and that depositing carbonate of magnesia are rendered permanently transparent. If urine be rendered turbid on being heated, in consequence of a deposit of earthy phosphates, the turbidity remains so long as the phos-

phates remain in mechanical suspension, and after a time they will be found occupying the bottom of the vessel, leaving the supernatant urine clear and free from cloud. If the turbidity result from carbonate of magnesia only, the urine on cooling becomes perfectly clear and free from either cloud or sediment.*

Pus.—The bladder naturally secretes mucus, but in certain diseased states this mucus becomes not only increased in quantity, but vitiated and greatly deteriorated in quality. There appears to be a great difficulty in distinguishing pus from diseased mucus. The globules of pus are surrounded by an oleaginous envelope soluble in ether; therefore ether digested on pus globules becomes charged with this oily matter, but receives no such impregnation from digestion on mucus.

A solution of chloride of gold causes the fatty matter from pus, or diffused in the urine by steatomatous tumours in the bladder, to form a film upon the surface, which may be readily recognised as fat or oily matter. Pus can only be confounded with mucus but independently of the microscopic characters; if to a purulent fluid in a tube, we add about its bulk of solution of caustic potash, ammonia, or of its carbonate, it is formed into a translucent, dense, gelatinous mass, often so solid and viscid that the tube may be inverted without displacing any of the mass. The liquor puris too is coagulable from the albumen which it contains. The gelatinous viscidity on the addition of liquor potassæ is the most distincive character.

Bile.—Urine, in certain cases of hepatic derangement, contains bile. This principle is detected by hydrochloric, but still better by nitric acid, which strikes a green colour with biliary urine. Dr. Golding Bird recommends the following plan for applying the nitric acid. Pour on a white plate a drop of the urine, and form it into an exceedingly thin layer, upon which let fall a drop or two of nitric acid. An immediate play of

* See a paper by the author in the *Medical Times*, Vol. xviii. No. 450, May, 1848.

colours, in which green and pink predominate, will appear round the spot where the acid falls, and thus indicate the presence of the colouring matter of the bile. Such urine is generally at first of a deep orange red colour, and prevails much in jaundice.

Semen.—Seminal urine is principally to be detected by the microscope, which renders apparent the *Zoosperms* and the *granula seminis* of Wagner. But it may be proper here to notice that we are much indebted to my friend Dr. Dawson, for having first more effectually directed attention in this country to the various phenomena and treatment of *Spermatorrhœa*, a disease hitherto almost wholly unnoticed and neglected by professional observers. None but those who have specially directed their attention to this complaint would believe the extensive prevalence of the disorder, and the numerous evils and misery which it entails upon the unfortunate and deluded victims of this wretched disease.

Having thus considered the composition of the urine in both its healthy and its morbid conditions, it may be a question whether it be possible, from any of the foregoing data, to determine with any degree of proximity to truth, the composition of the urine. Berzelius' analysis gives the ratio of the water to the solids as 933 to 67 in the 1000 parts. These 67 consisted of:

Urea . . .	30·10
Organic, or destructible principles; extractive, &c. . .	18·14
Inorganic, and indestructible salts .	18·76

We have here data sufficient to enable us to calculate, within certain limits, the composition of any specimen of urine, provided it contain no unnatural or abnormal principle. If, for instance, we assume any density 1·012, and multiply by 2·33, according to the rule already explained, we shall ascertain that 27·96 will be the amount of solids in 1000 grains or parts. "If then, says Aldridge, "the relative proportion of urea, extractive, and salts, be the same as in the specimen ex-

amined by Berzelius, the 27·96 grs. consist of 12·561 urea, 7·569 extractive, and 7·83 of inorganic salts."* Although there is no constant relation between urea and any one of the organic principles, yet it appears from numerous examinations, that the *sum* of all the organic principles maintains a very constant relation to the quantity of the urea, and in the proportion ascertained by Berzelius, viz. about as 30 : 18. Hence by determining the amount of urea, we may safely infer the amount of the other organic principles.

This rule, however, will not apply to the *inorganic salts*, the *quantity* and *proportion* of which are liable to be affected by a great variety of accidental circumstances. The kidneys are the outlets for almost all the soluble salines taken into the system; consequently their amount in the urine will be influenced by the nature and quantity of the various ingesta. Hence it becomes necessary to determine positively the amount of the inorganic, or more fixed principles.

Then let us suppose the sp. gr. as before 1·012 and the solids 27·96, and that by special analysis we have found the urea to amount to 14·35, and the fixed salts to 5· = 19·35: then 27·96—19·35 = 8·61, the amount of extractive and organic acids. "Or," says Aldridge, "you can ascertain the same thing by knowing that the constant proportion of the latter constituents to the urea is as 18 : 30, so that you can find the sum of organic extractives and acids by the following equation (27·96 — 5 = 22·96)

$$\frac{22{\cdot}96 \times 18}{18 + 30} = 8{\cdot}61.$$

Let us now take a case in which there is an abnormal principle, sugar for instance, as in diabetes; and assume the density 1·050. By experiment we determine the amount of the urea, and other organic principles; and also of the fixed salts. If we divide the sum by 2·33, as explained in a former page, we learn what the

* Lectures on the Urine, &c.

sp. gr. would have been had there been no abnormal principle. If, for example, experiment gave us 27·96 as the sum, then $27{\cdot}96 \div 2{\cdot}33 = 12$, and 1012 would have been the density but for the sugar. But the density is represented by $1050 - 1012 = 1038$ and ·038 is the excess over what would have been the density had there been no sugar. Then $\cdot 038 \times 2{\cdot}33 = 88{\cdot}54$, the amount of sugar in a thousand parts of such a specimen. We should therefore be justified in assuming the following as the chemical composition.

Urea	14·35
Extractive and organic acids .	8·61
Fixed salts . .	5·00
Sugar	88·54
Water . .	883·50
	1000·00

The mode of ascertaining the amount of urea has been already explained. To determine the fixed principles we have merely to evaporate a given weight of the urine to dryness. Heat the residue in a crucible of platinum, or of Berlin ware, over a spirit lamp, with double concentric wick, till it cease to fume. Then mix it with about half its weight of *red oxide* of mercury, and expose the whole to a full red heat. The oxygen of the mercury will convert the carbon from the animal matter into carbonic acid and carbonic oxide, both which will escape, and the mercury itself will be volatilized by the heat, and we shall have nothing but the saline and fixed principles in the urine. These collected and weighed will afford the information required.

To estimate the albumen in albuminous urine we have only to add a little acetic acid and filter, by which the uric acid will be separated. Then boil a known weight, and precipitate with a few drops of nitric or nitro-hydrochloric acid, throw the whole upon a *weighed*

filter, and wash with distilled water, acidulated with nitric or hydrochloric acid. Dry in a hot air chamber, and the weight of the filter subtracted from the sum of those of the filter and albumen, will give within a fraction that of the latter.

Dr. Aldridge directs the following:—"evaporate a known weight of urine, by means of a water-bath to dryness, washing the residue very well with boiling water acidulated with hydrochloric acid; dry and weigh. Every 2·33 grs. accounts for a unit in the density, and it is easy to calculate the deficiency of natural principles. Thus suppose sp. gr. 1020; quantity passed in 24 hours, two pints, problems consistent with health. Suppose 10 grs. of albumen in the thousand of urine, which would account for nearly $4\frac{1}{3}$ of the density, which, were no albumen present, would therefore be $1015\frac{2}{3}$; and a urine of this sp. gr. ought to be normally secreted in greater quantity, and we would consequently be justified in concluding such urine deficient in its solid constituents."*

OF CALCULI.

The constituents of calculi appear under three varieties of form—namely, the pulverulent or amorphous, the crystalline, and the aggregated masses. For a complete history of these and their pathology, I must refer to Dr. Prout's excellent work, and to my own lectures in the *Medical Gazette.*

If a portion of calculus or any other form of its constitution be examined chemically, it will give the same indications; consequently, what applies to one mode, will apply equally to all other forms and varieties of the same chemical constituents. Hence the chemical examination of calculi, and of those sediments so frequently found separating and subsiding from the urine is to be conducted upon the same principles; and the directions for the chemical examination of a calculus

* Lectures, &c. p. 43.

equally apply to the examination of the same principles when appearing as a mere sedimentary deposit in the urine.

The different calculi have been enumerated under the following species:—

1. Lithic acid calculus.
2. Lithate of ammonia.
3. Oxalate of lime.
4. Carbonate of lime.
5. Phosphate of lime, or bone earth calculus.
6. Double phosphate of Magnesia and Ammonia.
7. Mixed, or fusible phosphates, consisting of a mixture of 5 and 6.
8. Alternating calculus—the different constituents alternating in layers.
9. Mixed calculus, all the constituents confusedly intermixed.
10. Cystine, or Cystic oxide.
11. Xanthine, or Xanthic (lithic) oxide.
12. Fibrinous calculus.
13. Prostatic calculus.

Lithic acid is mostly of a reddish brown or fawn colour, approaching somewhat to that of mahogany; surface sometimes finely tuberculated; internally presents concentric laminæ; fracture either imperfectly crystalline or amorphous, and sometimes earthy. Heated before the blowpipe in the platinum forceps or on charcoal, it blackens, emitting a peculiar animal odour, and ultimately dissipates, leaving a minute quantity of a white ash, which is *alkaline*, reddening moistened turmeric paper. It is completely soluble in caustic potass, especially at a boiling heat—any insoluble matter being an impurity—from which it may be precipitated as a white granular, or sometimes gelatinous looking but crystalline mass, on the addition of a little hydrochloric acid, soluble also in basic alkaline salts. A small fragment placed in a capsule, with a little nitric acid, diluted with three times its weight of distilled water, dissolves with effervescence; on evaporation, the solution assumes

a pink or carmine colour, which is immediately converted, by a drop or two of ammonia, to a purple; the purpurate of ammonia of Prout—the murexide of Liebig. This diluted with successive additions of water passes through various gradations of colour to the palest rose red.

Lithate of ammonia forms the sediment which appears in the urine of persons suffering from dyspeptic affections, after it has cooled. It also forms, with the lithates of soda, potass, and lime, &c., the principal part of the lateritious and febrile sediments, being insoluble in the cold urine, requiring 480 parts of cold water for solution; it separates as the urine cools, and is re-dissolved on heating. When aggregated into a calculous mass it is mostly of a slate or clay colour; surface sometimes smooth, sometimes tuberculated; internal structure concentric; fracture very fine, earthy, resembling compact limestone, —much more soluble than pure lithic acid. It is rather uncommon; of small size, and mostly confined to children under puberty. It is often found intermixed with oxalate of lime. Heated before the blowpipe it crackles or decrepitates strongly. Heated in a tube with potass, or caustic lime, it gives off the smell of ammonia, and will turn moistened turmeric red, and will show the alkaline reaction upon other test papers, placed loosely in the mouth of the tube. It is soluble in the bi-carbonated alkalies (which the lithic acid is not), carbonate of ammonia and lithate of potass resulting from double decomposition.

Oxalate of lime or mulberry calculus:—usually of a dark brown colour or even black, and a rough tuberculated appearance like the mulberry; very hard and compact, and internally imperfectly laminated. It seldom surpasses the medium size, and is by no means uncommon. There is a variety dark in colour, smooth, and small, resembling hemp-seed, from which they have been named *hemp-seed* calculi. These are frequently intermixed with lithate of ammonia in every variable proportion. Oxalate of lime is generally very impure; but there is a variety nearly pure and crystallized; rather uncommon, rough, and sharp-angled.

Before the blowpipe, this calculus first blackens, then swells and expands into a kind of white efflorescence—carbonate of lime. If the heat be urged, caustic or quick-lime* is the only residue which reddens turmeric, and precipitates a solution of oxalic acid. It is soluble in hydrochloric and nitric acid, and precipitable without change by an alkali. It is insoluble in all the organic acids, even the acetic. To separate the acid, the oxalate reduced to powder should be well boiled with a solution of carbonate of potass: an exchange of principles is thus effected, and the filtered portion will contain *oxalate of potass*, and the oxalic acid may be identified by chloride of calcium, sulphate of copper, and nitrate of silver. The oxalate of silver from this last, on being dried and gently heated, detonates feebly.

If the pulverised oxalate be distilled with concentrated sulphuric acid, a gas comes over, which is reduced to half its volume by agitation with solution of the alkalies or alkaline earths, a *carbonate* of these bases being the result. The remaining volume proves to be *carbonic oxide.* Thus oxalic acid consists of equal volumes of carbonic acid and carbonic oxide.

Further, by digesting in dilute sulphuric acid, sulphate of lime will be formed, and the oxalic acid liberated will be set free.

Carbonate of lime—Before the blowpipe becomes caustic, and the residue precipitates oxalic acid. It dissolves with effervescence in the acetic, hydrochloric, or nitric acids, with the escape of carbonic acid gas. Calculi of this sort are very rare.

Phosphate of lime, though often forming a part of calculi, is very seldom found the exclusive constituent. The surface is of a pale brown, and so smooth as to appear polished, resembling porcelain; internally these

* The above are readily intelligible. Oxalic acid consists of carbonic acid and carbonic oxide. This last is first expelled, and carbonate of lime remains. On a continuance of the heat, the carbonic acid is expelled, and the lime reduced to the caustic state.

calculi are regularly laminated, and the laminæ adhere so slightly as to separate with ease into concentric crusts. They are striated in a direction perpendicular to the surface.

Before the blowpipe they blacken from the charring of the animal matter, and on continuing the heat they become white again, and resist all further action of the blowpipe, unless the heat be most intense, and which but few persons can raise, when they at last melt. This susceptibility of fusion distinguishes the earthy phosphate in calculi from that in bone, the latter containing more lime in its composition. The ash which remains has no reaction, either acid or alkaline. This last will distinguish the ash from those of the oxalate and carbonate above mentioned. It is dissolved by the acids—hydrochloric and nitric—and reprecipitable by caustic ammonia without decomposition, as a white powder not crystalline. It may be decomposed by boiling, or still better by fusion, with carbonate of potass, as noticed in respect to oxalate of lime.

Double phosphate of Magnesia and Ammonia is mostly of a white colour; surface uneven, covered with minute shining crystals. It is easily broken and pulverised. Sometimes, however, very hard and compact, and if broken, exhibiting a crystalline texture.

Before the blowpipe it becomes first discoloured, and then gives off ammonia, much more powerfully if a little potass or soda be previously added. The fragment diminishes in size, and ultimately melts. The fused mass consists of magnesia, with excess of phosphoric acid, the ammonia being driven off. Heated in solution of caustic potass it gives off ammonia. It is easily dissolved by diluted hydro-chloric and other acids, and may be precipitated, as a crystalline powder, on neutralising the acid by solution of sesquicarbonate of ammonia.

Mixed phosphates, or fusible calculus.—This variety consists of a mixture of the two preceding. It is white, and more friable than any of the other species,

resembling a mass of chalk. This calculus occurs frequently, and often forms an external coating, enveloping lithic calculi.

Before the blowpipe it melts with great ease, whence it is named "fusible." Dissolved in a dilute acid, on adding oxalic acid, oxalate of lime precipitates; and by treating the residual liquor with an alkali in neutralizing proportion, the double phosphate separates as a crystalline deposit.* The alternating and mixed calculi require no specific observations. Their constitution is to be determined by the due application of the different modes of analysis already pointed out.†

The phosphoric acid in the phosphates may be identified by the method recommended by Berzelius. Fuse the phosphate by heating with boracic acid before the blow-pipe on charcoal. The fusion complete, plunge the point of a fine steel wire through the bead, transfixing so that the point may project. Withdraw the bead on the wire, and heat it in the reducing flame. The iron oxydizes at the expense of the phosphoric acid, and borate of protoxide and phosphuret of iron result from the decomposition. The phosphuret fuses at a pretty high temperature, and the assay at first spread out over the whole length of the wire, after being heated resumes the globular form. As the globule cools, an appearance of ignition near the base may be in general observed. This arises from the crystallization of the phosphuret of iron. The globule, when detached, wrapped up in paper and struck gently with a hammer on the anvil, the phosphuret of iron separates, and appears as a small brilliant me-

* For more extensive directions, see Lectures in the *Medical Gazette*.

† The phosphates, as a class, generally may be distinguished by the caustic alkalies which have no solvent action, but merely disengage ammonia when a constituent. Diluted hydro-chloric acid readily dissolves them, from which solution they may be precipitated unaltered by any reagent that will neutralize or saturate the acid. The particular species of phosphate is to be determined by the means above detailed.

tallic globule, attractable by the magnet, and so brittle that it springs to pieces under a smart blow. If there were no phosphoric acid, the wire burns only at the ends projecting beyond the globule, retaining its brilliancy in the other parts.

Perhaps the best method is to heat and fuse these phosphates with the mixture of the carbonates of soda and potass.* The phosphoric acid unites with the alkali, forming soluble phosphoric salts, and the acid may be easily recognised by its generic chemical properties, and its amount determined.

To estimate the acid, precipitate the alkaline phosphate by acetate of lead. The phosphate of lead, collected, dried, and weighed, affords data for calculating the amount of the acid. This phosphate, fused upon charcoal with the blow-pipe, becomes, upon cooling, distinctly crystalline.

The amount of the phosphoric acid may be determined also by precipitating with peroxide of iron, and estimating the ferro-phosphate. Raciosky precipitates the acid in the salt in the state of phosphate of *peroxide of iron*. When this is done in an acid solution by means of acetate of peroxide of iron, the phosphate which falls is perfectly pure, and is represented by the formula Fe_2, O_3, P, O_5. All that is then necessary is to determine the amount of iron present, and from it calculate that of the phosphoric acid, as follows. The washed perphosphate is to be dissolved in hydro-chloric acid, and the iron reduced to the state of protoxide by means of *sulphite* of soda, and its amount determined by the quantity of a normal solution of *permanganate* of potass which it is capable of decolorizing, according to Marguerith's method. According to Dumas and Pelouse, the error by this method does not amount to more than from ·006 to ·008. Another method consists in dissolving the

* The fusion may be effected in a tube of hard glass over the lamp. A loose roll of moistened turmeric or reddened litmus paper in the open end of the tube will detect any escaping ammonia from either the phosphates or urate of ammonia.

earthy phosphate in hydro-chloric acid; then add solution of sesquichloride of iron in excess; a brown precipitate subsides—a mixture of *sesquiphosphate* and hydrated *sesquioxide* of iron. The latter is to be dissolved out by acetic acid; and the sesquiphosphate, after being well washed, is to be decomposed by digestion in solution of hydrosulphate of ammonia: sulphuret of iron, insoluble, and phosphate of ammonia result. The whole of the phosphoric acid is thus brought into the form of a soluble salt. These methods might be varied almost indefinitely; but enough has been detailed upon the subject.

Cystine, or Cystic oxide in many points resembles in appearance the double phosphate; it is, however, more compact, not laminated, but confusedly crystallized throughout its substance. These calculi exhibit a kind of yellowish transparency, with a peculiar glistening lustre, like a body of very high refractive density. Their consistency is about that of wax, and from a similarity of hardness, they affect the saw as wax would. It is often studded externally with crystals of the double phosphate.

Before the blowpipe it gives off a peculiar, but indescribable odour, quite different from that of lithic acid, and leaves a whitish ash, which is not alkaline. However, its characteristic properties are solubility in both acids and alkalies. Thus if dissolved in either an acid or an alkali, on the addition of the opposite reagent in neutralising proportion, it is precipitated in small yellowish crystalline plates, or granules. The acetic, citric, and tartaric acids, however, as also the sesquicarbonate of ammonia, do not dissolve it, but, on the contrary, precipitate it.

This calculus has been lately discovered to contain sulphur; by heat it is decomposed, and evolves sulphurous acid and ammonia. The formula for its constitution is $NC_6\,H_6\,O_4\,S_2$, that is, 1 of nitrogen, 6 of carbon, 6 of hydrogen, 4 of oxygen, and 2 of sulphur. This peculiarity of composition, and its containing sulphur, Dr. Prout considers as denoting its origin as resulting

from an imperfect assimilation of the albuminous principle, or more probably from the subsequent action of the kidney, on the such imperfectly developed albumen.*

Xanthine, or Xanthic oxide, is very rare, although I think it occasionally occurs in lithic concretions. It is mostly of a cinnamon colour; surface smooth; texture hard; compact; laminated; and the colour deepened by an alkali.

Before the blowpipe, it crackles, blackens, splits into scaly fragments, giving off a peculiar feeble animal odour, leaving a minute white ash. It dissolves in the nitric and sulphuric acids, but not in the hydro-chloric, or oxalic. It dissolves also in the caustic alkalies. On evaporating the solution in nitric acid, a bright brown yellow residue remained, whence the characteristic epithet "*xanthic.*" On analysis, its composition was found to differ from lithic acid, only in yielding less of oxygen. The formula of these two are as follows:

	N	C	H	O
Lithic acid . .	4	10	4	6
Xanthic oxide .	2	5	2	2

Hence the proposed name, "*lithic*" or "*uric*" oxide.

Fibrinous calculus.—Yellowish brown colour, like wax, and of the same consistence; texture fibrous, not stratified. On applying the flame of the spirit lamp, it takes fire, burns, swells, and blackens, ultimately passing into a carbonaceous ash. During combustion an animal odour exhales, different, however, from any of those before noticed. Its leading characters are solubility by digestion in diluted acetic acid; on adding a solution of ferrocyanide of potassium, a yellow precipitate falls down.

Prostatic calculi in some cases so closely resemble lithic calculi in appearance, that they can be distinguished only by their composition. They consist of phosphate of lime

* Researches on the Chemistry of the Blood, pp. 238, 239.

mixed with the secretion of the gland, and therefore the blowpipe will soon determine their nature.

*Siliceous gravel.**—Silex has been found in some cases forming small granular masses. Acted on by nitric acid, or the alkalies, they are not affected. Heated with a little of the mixed carbonates of soda and potass before the blowpipe, they readily melt with effervescence into a glass.

It may also be recognised by fusing before the blowpipe on platinum wire, microcosmic salt into a bead; then add the silex or the silicate, and expose to the oxydating flame. The glass bead while hot remains clear, and the separated silicic acid floats through it in a collected state; the bases combine with the free acid in the flux.

In many cases, especially in certain forms of rheumatism, and in some arthritic or gouty affections, lithic acid is formed in great abundance, and separates from the urine, as it cools, in the form of lithate of ammonia. It also frequently abounds in the blood, and is deposited in the joints, and in the sheaths of the tendons. These gouty concretions have been long known under the name of "chalk stones." They, however, consist principally of lithic acid and soda—lithate of soda. That the base is alkaline, may be shown by mixing the concretion with a small portion of finely divided silex, and heating before the blowpipe, when a bead of glass will be formed. The nature of the alkali may be verified by heating before the blowpipe, then fusing the mass upon a platinum wire. Soda will give a yellow tinge to the flame, while potass produces a violet.

There are various other concretions met with, from different organs in the human body, but a lengthened account of them would be foreign to the objects of this summary. Biliary concretions consist principally of cholesterine, or of the inspissated colouring matter of the bile. In some diseases the colouring matter accumulates so as to form solid masses. Its solution in caustic

* See a paper by the author in the Journal of the Royal Institution, N. S. 1829.

potass is of a clear yellow colour. It absorbs oxygen, becoming green. If therefore its solution be treated with nitric acid in excess, it is oxydised, and becomes a deep green. It is thus that bile may be detected in the serum of the blood, in the skin, the eyes, and as has been remarked already, in the urine of persons labouring under jaundice. If the nitric acid be not added in too great quantity at once, the yellow coloured liquor undergoes a variety of changes very rapidly, even in a few seconds, passing into green, then blue, afterwards violet, and finally red. After a short interval, this last also disappears, the solution becomes yellow, and the colouring matter is completely decomposed. The colouring matter is precipitated also, from its solution in potass, in flocculi of a deep green colour, by hydro-chloric acid. These flocculi, treated with nitric acid, undergo the changes above noted, and are soluble in caustic, potass, and ammonia, with a rich emerald green colour. For the properties of cholesterine, of which biliary concretions mostly consist, I refer to the works upon organic chemistry.

It is necessary just to allude to two principles which have been announced by Liebig as existing in the urine, —Kreatine and Kreatinine.

Kreatine was discovered by Chevreul in 1835 in the flesh of animals, and his views were confirmed by Wöhler. It presents in the form of transparent colourless crystals of great lustre: soluble in 70, or 80 parts of cold water; but in a much less quantity, if boiling. Its taste bitter and somewhat acrid. The watery solution is not precipitated by nitrate of silver, the sulphates of iron or of copper, concentrated solution of chloride of platinum, nor diacetate of lead. It is perfectly neutral, but readily undergoes decomposition, if organic principles be present. When heated, it evolves ammonia, phosphorous acid, and a yellowish gas, which partly crystallizes, and the odour of prussic acid is evolved.

Boiled with barytic water, ammonia escapes, and car-

bonate of baryta is formed; but the kreatine is not completely broken up. In the solution a new substance —an organic base *sarcosine*—is found. It occurs in right rhombic prisms with acuminated extremities; is soluble in water; insoluble in ether, but sparingly soluble in alcohol.

If we add to a boiling solution of kreatine ten times its weight of hydrate of baryta, and continue the boiling till the evolution of ammonia ceases; the filtered solution contains only sarcosine and baryta. If the baryta be precipitated by carbonic acid, the filtered liquor evaporated yields *sarcosine.* This principle neutralises acids and forms salts. Thus hydro-chlorate and sulphate of sarcosine may be obtained, and also the double chloride of it and platinum. The formula of sarcosine is $N_1\ C_6\ H_7\ O_4$.

	N	C	H	O
1 eq. of kreatine . .	3	8	11	6
1 eq. of sarcosine . .	1	6	7	4
Leaves 1 eq. of urea	2	2	4	2

Liebig proves that the carbonate of ammonia evolved by boiling baryta with kreatine, arises from the decomposition of urea, by arresting the process while the carbonate of ammonia is being freely evolved. Nitric acid added to the solution gives crystals of *nitrate of urea.*

By the action of the stronger mineral acids aided by *heat*, kreatine is changed into *kreatinine.*

Kreatinine.—A colourless crystalline substance, much more soluble in cold water than kreatine, requiring but eleven and a half parts for solution. A thousand parts of alcohol at 60° take up 9·8 parts of kreatinine. It is a strong alkaline base, readily combining with acids, and with many of these forming crystalline compounds. It displaces ammonia.

Liebig ascertained that kreatine disappears during the putrefaction of urine; but that kreatinine remained unaffected under the same circumstances. He also succeeded in converting kreatinine into another basic prin-

ciple, sarcosine. And from flesh containing kreatine, he obtained an acid principle which he named *Inosinic* acid.

The following is, according to Liebig, the composition per cent. of these two principles, evidently distinguished, some years since, by Pettenkoffer:—

	Kreatine (Crystallized)	Kreatinine.
Nitrogen - -	28·19	37·17
Carbon - -	32·22	42·48
Hydrogen - -	7·38	6·19
Oxygen - -	32·21	14·16
	100·00	100·00

Having thus detailed the general and chemical properties of both healthy and diseased urine, it only remains to offer a few observations upon the mode of conducting analyses, and to address them principally to the inexperienced in those matters.

The first object should be to become acquainted with the general appearance and properties of healthy urine, and the reagencies produced by the different tests, because when familiar with properties belonging to health, disease is instantly recognised.

Urine which has a *yellow* or deep orange-red colour, indicates a mal-distribution of the bile, and denotes a tendency to, if not actual jaundice. *Copper*-coloured urine, which is or becomes remarkably transparent on cooling, indicates acidity of this excretion, and a tendency to deposit *lithic* acid in the crystallized form. *Citron*-coloured, or *yellowish*-green coloured, remarkably transparent, with an acidulous reaction, denotes the oxalate of lime diathesis. *Pale straw*-coloured urine, or of a *bluish-green* tint, and having *the smell of new hay*, denotes sugar, and the presence of diabetes, in some one or other of its forms. *Opalescent oily-looking* urine. having a peculiar animal odour, also resembling that of the sweet or *wild briar*,* denotes the *cystic oxide* diathe-

* See a paper by the author published in the Journal of the Royal Institution Vol. XX1X, January 1830.

sis. *Pale-coloured*, *wheyish-looking* urine, *opalescent*, when passed, and having a strong peculiar urinous smell, is generally *neutral*, and soon becomes *alkaline;* it denotes a tendency to the *phosphates*. Very *clear colourless transparent* urine, devoid of *smell* and almost of *taste*, is generally copious, watery, and of very low sp. gr.; shews a tendency to hysteria, and various other nervous affections, as well as spasm. Urine of this sort also contains a large proportion of the alkalies, mostly carbonated. Urine perfectly *transparent* when *passed*, but becoming *cloudy* as it *cools*, and finally depositing *reddish*, *yellow*, or *cream coloured* sediments, shews a predominance of *lithate of ammonia*, and the sediment will readily dissolve on the application of heat. Urine *cloudy* when *passed*, and remaining so after *filtration*, but on being heated after the addition of a little *acetic acid*, becomes *opaque*, and deposits a *solid coagulum*, contains albumen in some one or other of its modifications. Urine transparent when warm, but which on cooling deposits a sediment, and being heated becomes again transparent, but on continuing the heat becomes cloudy, and ultimately deposits a coagulum, owes these properties to lithate of ammonia in excess, with albumen. A very slight degree of temperature dissolves the lithate, but it requires a temperature of between 150° or 160° Fah. to coagulate the albumen; the double opalescence, with intervening transparency, arising from the different degrees of temperature. Transparent urine, becoming cloudy on the application of heat, will be found to owe that property to holding the phosphates, and probably some carbonate of lime in solution by carbonic acid in large excess.

The quantity of urine passed in a given time should be attended to, for although of itself or abstractedly it may lead to no particular inferences, yet in connection with other circumstances, quantity forms an object of no small moment. This matter, however, belongs entirely to the patient's observance.

Having examined the sensible, the pathologist next

proceeds to the mechanical properties, namely, the sp. gr., and this is often quite sufficient to lead to very important information. By immersing the urinometer, and allowing it to remain at rest for a few seconds, the sp. gr. is at once read off by mere inspection of the figures on the stem. The following precautions, however, are essential to accuracy and precision. The instrument should be perfectly *clean*, and free from all *grease*, *oily*, *mucilaginous*, *saccharine*, and *saline* particles, the adhesion of which affect the delicacy of the instrument. The urine, too, should be free from all *bubbles of air*, which, by attaching themselves to the stem of the instrument, would give it a greater degree of buoyancy, and consequently lead to a false estimate. The temperature also should be taken, and this should be allowed to approach the ordinary standard, say between 50° and 60°, before the sp. gr. be finally determined. Urine below 1·010, very copious, clear, and like spring water, infers defective digestion, attended with a cold phlegmatic constitution. Often, too, the alkalies predominate. Copious, pale-coloured urine, of sp. gr. between 1·015 and 1·020, denotes spasm; indeed, urine copious, like spring water, and of low sp. gr. from 1·000 nearly to 1·015 indicates a leucophlegmatic habit, a watery serous condition of blood, and what would be designated an anæmious condition of the system. Such urine also frequently contains imperfectly elaborated chyle. To these, however, there are some exceptions, which the other conditions of the urine indicate.

Urine of similar properties, but opalescent or wheyish and neutral, or which speedily becomes alkaline, shews a tendency to the phosphatic diathesis. Phosphatic urine, however, is frequently of much higher gravity—from 1·020 to 1·025—and then frequently abounds in urea.

It may be here observed that an alkaline reaction in the urine may arise from the presence of either carbonate of ammonia, or, as previously observed, that of the carbonated fixed alkalies. The first depends upon the

gradual decomposition of urea, and the transformation of its elements into carbonate of ammonia. Hence the gradual and steady deposition of the prismatic phosphate, even from urine, with acidulous reaction. Such urine contains depraved mucus, mostly intermixed with pus. The deposit, as the evolution of the ammoniacal carbonate proceeds, becomes ropy and glutinous, or adhesive; the urine at the same time having become *alkaline.*

Urea does not undergo spontaneous decomposition; but when the mucous lining of the urinary cavities or passages are in a state of inflammatory irritation, a muco-purulent exudation is thrown off from its surface, which, acting on the urea, decomposes it, and the evolution of carbonate of ammonia is the result. At first, the carbonate being in but small quantity, the urine preserves its acidulous reaction; and thus the prismatic crystals deposit from urine with acidulous reaction; but as the quantity of the carbonate increases, the urine assumes an alkaline reagency; for it is seldom voided alkaline with deposits of the double phosphate, but rather acquires alkaline properties after being passed.

Alkalinity may arise from the carbonates, or the basic salts of the fixed alkalies. The presence of these carbonates causes a precipitation of impalpable phosphate of lime. This may be recognized by its amorphous opaque appearance under the microscope, and by its chemical properties. These phenomena may have origin in the following modes. If the individual be taking the fixed alkalies or their carbonates, the urine may be rendered alkaline, and the impalpable phosphate be precipitated. Again, the salts of the alkalies, with an *organic* acid as the salifying principle, readily undergo decomposition "in transitu," and appear as carbonates in the urine, and may cause the precipitation of the phosphate. Farther, in certain morbid conditions of the digestive functions, the carbonated fixed alkalies appear in the urine, and give rise to the phosphatic phenomena under consideration. In drawing our conclusions, therefore, we should inquire minutely into the special

causes. If from either of the two first, the alkalinity will be transient, disappearing as the remedial agents, its cause, are discontinued, but reappearing again upon their resumption.

But when the alkalinity and phosphatic deposit depend upon indigestion or derangement of the digestive viscera, the phenomena will be permanent, nor will they disappear upon laying aside the use of alkaline remedies.

These two forms of urine affect tests in a peculiar way; ammoniacal urine turns reddened litmus paper blue, and reddens turmeric; but owing to the volatility of the ammoniacal salt, the reddened turmeric paper on drying becomes yellow again, and the litmus reassumes its previous red colour.*

The prismatic crystals then consist of the double phosphate of ammonia and magnesia, the ammonia being furnished by the decomposed urea, and when accompanied with muco-purulent ropy urine indicate inflammatory irritation of the urinary mucous lining. Here antiphlogistic means are best suited. But in the case of the phosphate of lime there appears to be an atonic condition of system, feeble innervation, and a weakened and impaired state of the digestive powers.

* It is of some moment to determine whether an alkaline reaction be owing to the presence of the carbonate of the volatile, or of the fixed alkalies. For this purpose half fill a test tube with the urine, and let fall into it a drop or two of hydro-chloric acid. If the reaction be owing to carbonate of ammonia, a dense white cloud of hydro-chlorate of ammonia will be formed, occupying all that part of the tube above the level of the urine. A loose plug of moistened turmeric or of reddened litmus-paper, placed in the mouth of a tube similarly circumstanced, will reveal the presence of ammonia, the turmeric by becoming reddish-brown, the litmus blue—changes, however, speedily evanescent. When the quantity of ammoniacal carbonate is very small, it may be necessary to heat the urine to volatilise the ammonia and effect the changes. We thus determine the presence of carbonate of ammonia. If the alkaline reaction upon test paper immersed in the urine continue permanent, then we infer the presence of fixed alkali; while the previous characters prove that of the volatile; the deposit will be found to consist of both prismatic crystals and impalpable phosphate of lime—the mixed phosphates.

When the sp. gr. exceeds 1·018 or 1·020, has a deep colour approaching to red, high-coloured as it is termed, phlogistic fever may be considered as habitual, and indigestion, with hepatic derangement, is present. In such instances the alkaline lithates often abound and are deposited. Urine from 1·020 to 1·025 or 30, of an ale or porter colour, attended either with diuresis, or with a desire of frequent micturition, indicates excess of urea, a tendency to diabetes, and not unfrequently either hœmorrhoids are troublesome, or the prostate gland is in some degree affected. A sp. gr. of 1·030, (and above more certainly,) transparent, of a pale-straw colour or bluish green, most unequivocally denotes diabetes, nor does a saline taste alter the facts; for, though saline, sugar may be proved by some of the ordinary methods of search.

From the above we are often guided to the application of chemical tests. Thus if we suspect urea, we ascertain this either by nitric acid or a solution of the oxalic, as before pointed out. If we suspect lithic acid, we can readily precipitate it by the acetic or hydrochloric. If an excess of the alkalies, we throw down bitartrate of potass by tartaric acid; and still more copiously by adding a little alcohol. Solution of potass or ammonia will shew a greater or less proportion of the phosphates, and we judge of the quantity by comparing the bulk of the precipitate obtained with the volume of urine used. A drop or two of acetic acid, and the solution of prussiate of potass will almost immediately coagulate albumen, and produce cloudiness, and ultimately a solid coagulated deposit.

It is presumed that enough has now been stated to enable any person to make use of the cabinet, and properly to apply the different articles and apparatus to discover the morbid conditions of the urine. Having done so, he will then be able to understand the indications which they afford, and to consult the various authorities upon urinary diseases, with all the advantages which can result from an adequate knowledge of the subject.

MICROSCOPICAL ANALYSIS.

The microscope furnishes us with a very ready means of subjecting any deposit in the urine to examination. Many principles will hardly admit of any other possible mode; and further, many other principles admit of the most expeditious means of determining their nature by the microscope. This instrument is therefore of essential importance in the examination of certain urinary sediments.

For the purposes of general analysis, an instrument with a $\frac{1}{2}$ or $\frac{4}{10}$ inch object glass with *extra wide aperture*, or enlarged, will be all that will be necessary, but in certain rare cases a deeper objective will be required. Supports, are slips of glass about three inches in length, one in breadth, and about a twentieth or twenty-fourth of an inch in thickness. They should be of white glass, and a number kept in readiness. Slips of very thin glass, thickness about the $\frac{1}{50}$th of an inch, and varying in size from half an inch to an inch square, are also necessary to cover the object; all which can be obtained at the publishers'.

When the deposit has subsided, the supernatant fluid is to be poured off, a portion of the sediment may be taken up by means of a pen or a camel-hair pencil, or dropping tube, and thus sufficient transferred to the slide and examined. When expedition is of consequence, and the spontaneous subsidence would occupy too much time, a quantity of the urine, turbid with the suspended deposit, may be thrown on the filter, and passed through rapidly. What is retained may be washed from the sides, and collected at the bottom of the filter by a capillary stream of water from a dropping tube drawn out to a capillary point, and then a portion transferred to the support, by a feather or camel-hair brush, as before noticed. By the plan

of filtration* a sufficiency of any urinary sediment, or even artificial precipitate may be collected and prepared for microscopic observation in a very few seconds, but various plans will constantly suggest themselves to the ardent enquirer.

To acquire a knowledge of the appearance of the different deposits from the urine constant observation is necessary, but many are easily separated from almost any specimen.

Urea. This principle is readily obtained in the form of nitrate or oxalate from urine reduced by previous evaporation to one half or one fourth its original bulk. The crystals, when dried and purified, appear in thin silky plates. The appearance is shewn in (Fig. 1.)

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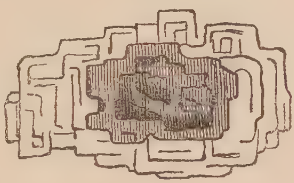

Its chemical properties, however, detect it more easily. Pure urea may be examined by evaporating a drop or two of its alcoholic solution upon a slip of glass.

Urea has a singular effect upon the crystallization of chloride of sodium. This salt crystallizes naturally in *cubes*, but urea causes it to assume the *octohedral* outline. But if to a few drops of solution of the chloride, a drop

* I usually keep a number of these filters ready, so that one can be placed in a small funnel and a few drachms of urine run through in a few seconds. If the sediments consist of mixed principles, urate of ammonia, oxalate of lime, and earthy phosphates, heat removes the urate, and acetic acid will dissolve out the phosphates, leaving the oxalate alone. Again, lithic acid may be removed by digestion in the basic salts of the alkalies ; but when the object is to retain the lithic acid, digestion in hydro-chloric acid will leave this principle isolated.

or two of urine holding urea in solution be added, and the whole evaporated quickly, the octohedrons of the chloride are replaced by a series of elegant crystals assuming the appearance of crosslets and daggers. (Fig. 2.)

2

This phenomenon Dr. Golding Bird asserts is a tolerably safe indication of the presence of urea.* These crosslets &c. are evidently mere modifications of the octohedron; mere distortions of the octohedral outline.

Lithic, or Uric Acid,—readily precipitates from the urine, concentrated by evaporation, and warm, by hydrochloric or almost any other acid. By spontaneous separation, or when pure, it assumes the crystalline form, and appears mostly in rhombs. Its various appearances are shewn in Fig. 3.

3

Some of the forms, though coloured, are very transparent, and are visible by light from the mirror passed or transmitted through them; but the rhomboidal prisms and aggregated spines are best seen by condensed, called reflected, light, as from a Leiberkhun thrown upon them

* On Urinary Deposits, Ed. 2. p. 147.

supported on a black ground. Upon one occasion I observed a beautiful heart-shaped crystal of uric acid resting upon a square table,—the outline is given in the figure.

Lithate, Urate of Ammonia. There is nothing very peculiar in the microscopic appearance of this salt.

The lithic acid in their composition may be readily demonstrated by warming a small portion of the turbid urine, and when it has become transparent, adding a drop or two of hydrochloric acid, when, after a short time, lozenge-shaped crystals of lithic acid will be seen separating.

Oxalate of Lime. Until the researches of Dr. Golding Bird, this compound had not been distinctly recognized as a urinary deposit, and was known only when aggregated as calculous masses. Dr. Bird has shown that crystallized sediments of this salt are often to be discovered in the urine; they are very often intermixed with the alkaline lithates, phosphates, epithelium, and even other principles. These crystals, owing to their refractive density and power, being pretty nearly equal to that of the urine, are not so easily recognizable, while diffused, by the unaided eye. When the urine has been replaced by water they become distinctly visible. Their discovery, therefore, requires some little management.

Dr. Bird directs the urine to be set apart to allow the sediment to subside. Pour off the upper six sevenths of the urine, transfer a portion of the residue to a watch-glass, warm gently to dissolve any urate of ammonia, and the sp. gr. of the urine being thus reduced, the crystals sub-

side. Remove the urine by a pipette, and replace it by distilled water. A white powder, glistening like diamond dust, becomes distinctly visible.

The above plan requires time, and perhaps is not quite so manageable. The following will be found convenient. If the urine be turbid, heat it to dissolve the urate of ammonia, throw it on a filter, and wash down any adhering salts by a fine stream of warm distilled water, and afterwards by solution of carbonate of potass; any oxalate of lime will be found collected at the apex of the filter cone. If the presence of phosphates be suspected, they may be carried through in solution by a similar process with warm diluted acetic acid, and lastly, washing with distilled water. The filter may be now removed and opened out on the filter drier. Apply a feather, camel-hair brush, or what is preferable, the end of a cork, to that part of the filter upon which the crystals have been collected. An abundance will be found adherent, and by touching the slide with the end of the cork, a large number will be transferred ready for microscopic observation. If the filter be folded up again, replaced in the funnel, and its apex perforated with a wire, the crystals may be washed through into a glass jar or bottle by a stream of water as before, and their appearance in clear water to the naked eye exhibited. This process has the advantage of great simplicity, expedition, and may be readily performed by any, even the least conversant with chemical manipulations.

The oxalate of lime crystals examined with a $\frac{1}{2}$ or $\frac{4}{10}$ inch objective enlarged, appear remarkably transparent, presenting an octohedral outline with remarkably sharp edges and angles, Fig. 5. If rapidly dried on the

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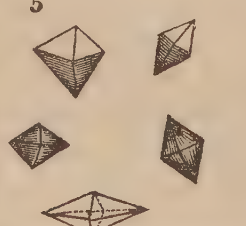

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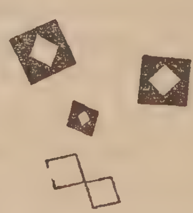

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slide, they present the appearance of two cubes, one enclosed within the other, the angles of the one being opposed to the sides of the other, the exterior frequently dark while the interior is transparent. (Fig. 6.) Occasionally the oxalate of lime assumes the appearance of dumb-bells, or of two kidneys with their pelvic edges opposed. (Fig. 7.)

Deposits of this salt seem to be intimately associated with urea, uric acid whether free or combined, and, according to Prout, with the saccharine principles. The sp. gr. of urine in which this salt is present is generally that of medium density, oscillating about 1·020, but may be considered as mostly high, that is above 1·020. The urine generally contains an excess of urea and a large quantity of epithelium, and when the crystals are most abundant the excess of urea is for the most part the greatest, in many to such an extent that nitric acid causes almost instantaneous and most complete crystallization.

The appearance of oxalate of lime is unquestionably intimately connected with functional derangement of the digestive organs, especially of the stomach, duodenum, and liver. This may be readily conceived when we come to consider how much the appearance of oxalic acid seems to be under the *control* of *diet*. It has been often observed that certain injesta, or food perfectly free from oxalic acid, and even of its compounds, still cause its appearance in the urine, while it wholly disappears under the use of a different kind of diet. Emaciation, or at least a spareness of habit is usually one of the attendant phenomena, and there can be little doubt that its appearance indicates that the assimilative powers are deeply involved. This salt often abounds in the urine of persons disposed to gout.

Earthy phosphates consist of the phosphate of lime and of phosphate of magnesia, the latter combined with that of ammonia. Phosphate of lime can hardly be looked upon as of urinary origin; scarcely ever appears crystallized; is mostly amorphous, and requires no microscopic observation.

Double phosphate of magnesia and ammonia.—Of this there are two varieties, the *neutral* or *prismatic*, and the *basic* or *stellar*.

Prismatic often forms an iridescent pellicle or film upon the surface of the urine, when it is disposed to separate. It is also found attached to the sides of the jar or bottle in which such urine has stood. In some cases it is found in the urine, even as it passes from the bladder, for its existence is not incompatible with an *acidulous* reaction of this fluid. It is very often precipitated from urine that has been long kept, owing to the decomposition and conversion of its urea into carbonate of ammonia. It may be readily artificially obtained, and in the space of a few seconds, for observation, by adding to urine passed after the digestion of a meal has been completed, the density ranging from 1·018 to 1·025, a few drops of a solution of sesquicarbonate of ammonia—half a drachm of the salt to one fluid ounce of distilled water.* The addition may be just sufficient to, or perhaps short of, neutralizing the natural acidulous reaction of the urine. The prismatic crystals speedily begin to subside, and in a short time not only will the upper surface be covered with a film, but the sides of the glass or jar will be found studded with adhering crystals. The film may be skimmed off by means of a spatula and transferred to distilled water. By pouring off the water after washing they are easily transferred to a slide by the methods formerly mentioned, and so viewed.

These crystals appear as beautiful triangular and quadrilateral prisms; the forms frequently well defined, with sharp angles and edges. (Fig. 8.) The triangular is the most common form, but there is great variety in their terminations, their edges sometimes bevelled off, and the terminations not unfrequently replaced by facets. These crystals are remarkably transparent and wholly

* This solution will precipitate the prismatic phosphate from almost every urine.—Ammonia throws down the basic salt.

devoid of *colour*; sometimes, however, they have an *enamel*-like appearance which may be readily communicated by boiling them. In such circumstances they can be viewed only as opaque objects, by condensed or by reflected light, as under a Leiberkhun.

Although the above method is very expeditious, still to obtain large splendid crystals longer time must be given. But where the object is the instantaneous exhibition of prisms, we have only to take a drop or two of urine, add to it, placed on one of the supports, about a third or half its bulk of the solution of sesquicarbonate of ammonia, and place for a few seconds upon a warm iron plate or hob, when a crop of very minute prisms, variously marked, will be seen to have formed throughout the extent of the urine. So small or minute are these crystals, that with a low power they appear merely as blackish-looking spots or points, which glisten occasionally, as the light by moving the mirror is made to dart through different parts of their substance. In some they appear somewhat like an X, and in others like the Greek $\varkappa$* (Kappa).

Sometimes the salt appears as simple stellæ, these are minute needles aggregated together into minute calculous masses. They adhere by one extremity round a central point or nucleus, and diverge toward the circumference, like the radii of a circle. They show best on a black ground.

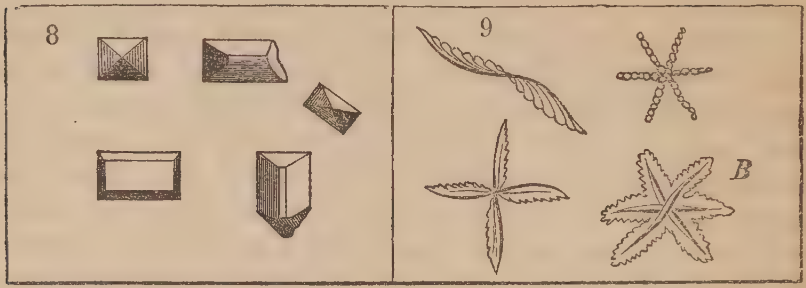
Pterygoid crystals. These, named by Dr. Golding Bird, who seems to have been the first to notice them, *penniform*, have been but recently observed. "It presents," says Dr. Bird, "the appearance of striated feather-like crystals, two being generally connected so as to cause them to resemble a pair of wings." (Fig. 9.)

Basic, or bibasic double phosphates, (Fig. 9, B.) as of external or artificial formation, require no comment.

Carbonate of lime. It seems almost unnecessary to

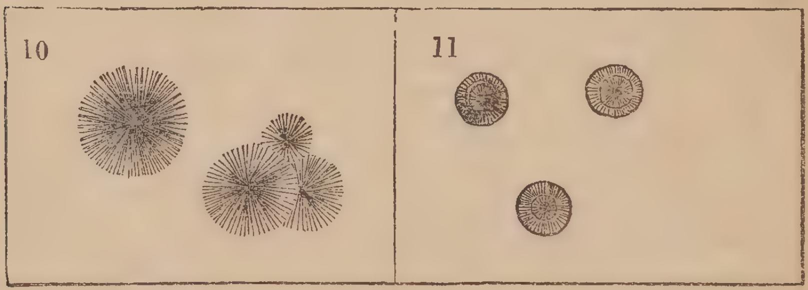
* See the Author's Papers in the *Med. Times*, 4th December, 1847, and 13th May, 1848.

refer microscopically to this principle, it is so very rarely



met with crystallized in human urine, although often abounding in the urine of the herbivora. It is supposed to result from the precipitation of the calcareous salts in the urine by carbonate of ammonia, formed from the transformation of urea. Upon some occasions, however, I believe carbonate of lime, however originating or generated, is often held in solution by *free* carbonic acid, which escaping under favourable circumstances, the carbonate of lime precipitating slowly assumes the crystalline form, attaching itself to the sides of the jar,* as many other saline crystals have been observed to do.

In some instances it is found crystallised in stellæ, (Fig. 10.) proceeding from the centre and radiating



towards the circumference of a circle. Viewed with polarised light, a black cross may be seen if the polarising prisms be properly adjusted. The carbonate of lime from the urine of the horse presents a different appear-

* See an article published by me, many years since, in the Journal of the Royal Institution.

ance (Fig. 11.) from that obtained from the urine of man.

Epithelium, a species of cuticular exfoliation secreted and thrown off as a sort of debris by the mucous membranes. There are several varieties enumerated, viz. scaly, or tesselated; cylindrical; prismatic, or columnar; and the spheroidal, or glandular; and these may be ciliated, or non-ciliated. It is not unfrequently mistaken for mucus, from which it may be distinguished by their microscopical characters. Fig. 12, shows the epithelium as indeed usually seen.

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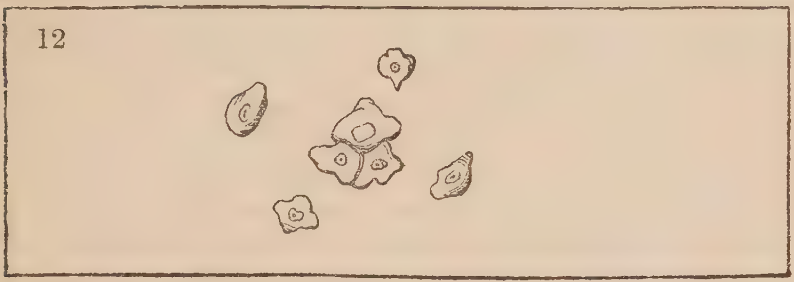

*Cystine.** This principle is very soluble in ammonia, and alkalies generally. Its ammoniacal solution being allowed to evaporate spontaneously and slowly upon a glass slide, the cystine crystallizes in very short hexagonal prisms, or six-sided plates. (Fig. 13.) The

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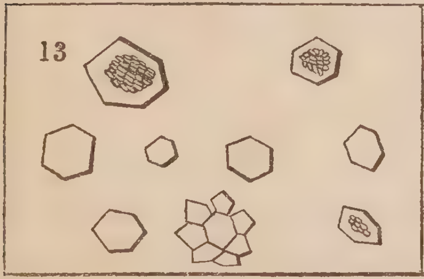

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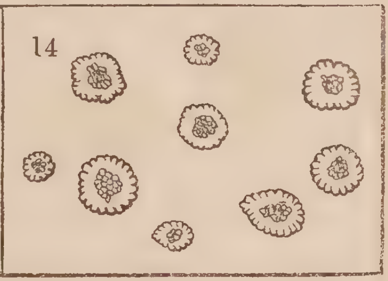


* Woollaston, its discoverer, named this principle *Cystic oxide*. Marcet proposed, from its origin in the kidney, the name *Renal* oxide; for both which *Cystine* has been lately adopted, but upon principle equally objectionable; perhaps *Nephrine* would be more consistent and more free from objection than any name hitherto proposed.

evaporation must be slow, so that the crystals may be very thin, otherwise the crystallization will be irregular, and confused at the centre, leaving the margins, however, perfectly transparent.

Cystine never appears in the amorphous form, but always crystallised. The plates are always serrated or crenated at the margins. (Fig. 14.) These serræ appear to be the sharp angles of numerous plates placed one upon the other, and the whole surface is traversed by lines which are merely the edges of other and distinct crystals. Viewed with a Leiberkhun they appear like rosettes. Crystals of double phosphate are seen not only attached to calculi of cystine, but also intermixed with sediments of this substance. Acetic acid will dissolve the prisms of double phosphate and leave the cystine intact. Examined by polarised light, the crystals of cystine display a variety of beautiful tints. Chloride of sodium might lead to error, as in crystallizing under certain circumstances it assumes a *three*, *four*, or *six-sided outline*, which might be mistaken for the laminæ of cystine.* But the ready solubility of the chlorides in water, and their inaction upon polarised light, afford an easy method of distinguishing them. The oily properties of the urine, too, and its sweetbrier odour will readily identify cystine.

Mucus appears as amorphous granules, intermixed with epithelial scales, and with globules like those of pus. These globules swim in a fluid, "*liquor muci*," which may be coagulated. The action of acetic acid is peculiar and characteristic; it coagulates the liquor muci, causing the whole to assume the appearance of an opaque corrugated membrane. The particles develope an internal nucleus, like pus, but not near so numerous, nor is the granular appearance so distinct as in the nuclei of pus.

Pus, like mucus, consists of globules swimming in a peculiar fluid, *liquor puris*. These globules are spheroidal, develope nuclei from one to five in number, (Fig. 15.)

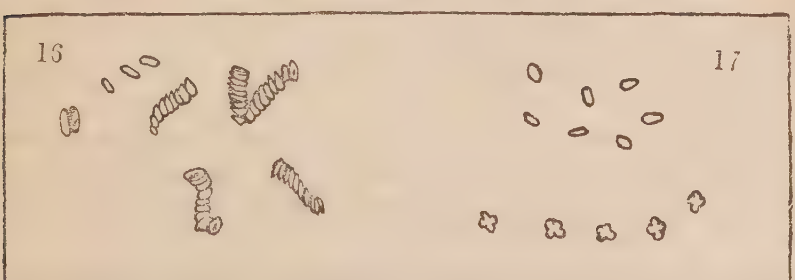
* Golding Bird.

which again develope smaller ones, *nucleoli.* Acetic acid dissolves the exterior, leaving the nuclei intact.

Mr. Queckett has ascertained that a peculiar character distinctive of the mucous granules is their *incessant motion* ;* no motions are to be observed in those of pus. Their characters may be thus contrasted :—

Mucus.	*Pus.*
A globule with nucleus, and granular bodies in constant motion.	A globule much smaller, granular bodies perfectly quiescent, without any tendency whatever to motion.

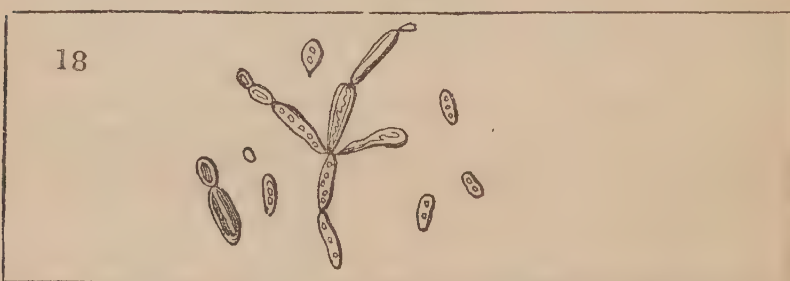
Blood. The red particles are the only parts suited for microscopic observation ; they are flattened discs ; they are readily recognised by their uniformity of size, their yellow colour, and their presenting nothing of a granular appearance. When the effusion into the bladder has been recent the discs appear in rouleaux, (Fig. 16) ; but when the blood is but very small in



* For this observation a deep objective, one-twelfth inch focus, is required.

quantity, or the effusion less rapid, the blood corpuscles appear floating distinct and separately in the fluid. (Fig. 17.)

Torulæ Diabeticæ. Diabetic urine left in a warm place for some time, like other saccharine solutions, becomes covered on its surface with a whitish frothy scum, somewhat like flour, a sort of confervous vegetations, passing through various stages of development. At first their figure is oval, having granules in their interior, by the development of which they enlarge. As they expand, they dilate the oval or spherical vesicle, within which they are enclosed, forming them into elongated tubules. The internal granules becoming enlarged, and more transparent at last, protrude from the exterior of the transparent cell, like buds. As the globules expand they become elongated, forming long, slender, jointed growths; and, ultimately, breaking, evolve an abundant crop of oval vesicles, or spores, which subside and germinate. These spores, placed in a weak solution of sugar, speedily germinate, fermentation is induced, and a new crop of torulæ produced. (Fig. 18.)



18

This fermentation must not be confounded with the mucous one, preceding a viscid, ropy transformation of this principle, and peculiar to habits debilitated by scrofula, syphilis, and other forms of cachexy.

Dr. Prout describes a sort of cyst, of very small size, which he has observed in the urine of persons labouring under disease of a formidable character. "Under the microscope," says this eminent authority, "the appear-

ance consists of small cysts of an oval or sometimes of a spindle shape, adhering to each other by their small ends, like a string of beads. I have seen as many as six thus connected in a line, but three or four are more usual, and frequently, instead of being connected in a single line, they are associated in other ways, as attempted to be represented in the plate. I have generally found this appearance along with the oxalate of lime in malignant diseases; in certain skin diseases connected with confirmed hypochondriasis, or with insanity, &c.*"

The urine in many of these cases is not serous, nor in any other of its properties does it indicate disease of the kidneys.

Seminal urine is characterized by the presence of spermatozoons or zoosperms, and the seminal granules of Wagner. (Fig. 19.) For their discovery the last

19

drops, expelled by the spasmodic actions of the acceleratores urinæ seu ejaculatores seminis, should be chosen. The oozing from the patulous ducts is thus driven out into the urethral canal and mixed with the last drops of the urine. In such cases the urine is often loaded with oxalate of lime.

In confirmed spermatorrhœa there is generally an oozing from the urethra, and if the plane of one of the slides be applied to the orifice of the urethra, and the adhering matter examined under the microscope, the spermatozoons, if any be present, will be readily seen, and once seen, cannot fail after of being recognized.

* On Stomach and Renal Diseases, p. 192.

Their form and appearances are shown in the figure above.

I have now laid before the reader the principal phenomena to be investigated as the chief auxiliaries in urinary pathology and diagnosis. The interest which inquiries of this kind have lately excited, and the zeal with which they are prosecuted in the present day, render some knowledge of the subject an essential to even ordinary medical education and proficiency; and should this little summary prove of any assistance in the acquirement of such knowledge, the principal object of its author will have been attained.

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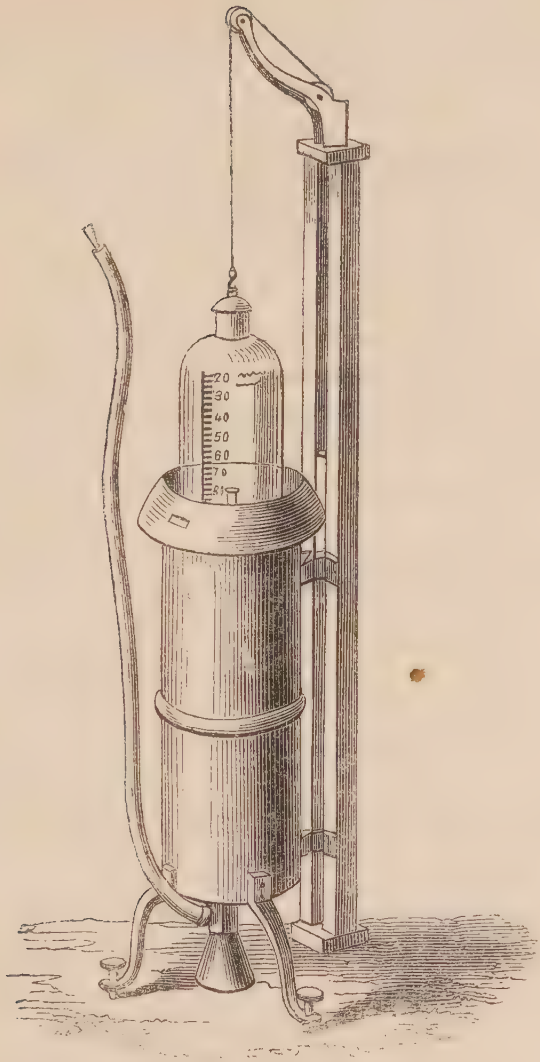

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